SMC
Systems Engineering
Specialty Engineering Disciplines

Framework and Descriptions

Space & Missile Systems Center
U.S. Air Force

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SMC Systems Engineering

Specialty Engineering Disciplines Framework and Descriptions

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Specialty Engineering Discipline (SED) Framework Overview

The SED framework includes the essential activities, tasks, and products that shape the body of knowledge for each SED. A SED framework is essential for each engineering discipline to effectively scope, plan, staff, and execute engineering activities and to ensure that each discipline's contribution is timely, adequate, consistent, and compliant to support development, deployment, and sustainment of the SMC space portfolio of programs and systems. The SED framework captures the SEDs identified in Table 1 below.

Table 1 List of SMC SEDs

SMC Specialty Engineering Disciplines
Systems Engineering
Test & Evaluation
Software Engineering
Integrated Logistics Support
Design Engineering
Manufacturing and Producibility
Quality Assurance
Reliability and Maintainability
Spectrum Management
Concept Development
Architecture Engineering
System Safety Engineering
Acquisition Systems Protection & International Program Security
Survivability
Human Systems Integration
Mass Properties
EMI/EMC
Parts, Materials & Processes
Information Assurance
Netcentric Engineering
Environmental Engineering
Prognostics, Diagnostics Health Management

Standard SED Framework Characteristics and Parts

The SMC SED framework is designed to characteristically capture the following attributes:

1. Provide SED contributions to all major SMC acquisition activities while accounting for acquisition phase dependencies.
2. Integrate with the overarching Systems Engineering activities and adjunct Specialty Engineering activities.
3. Integrate with the program and project management activities.
4. Comply with technical mandates, regulations, and objectives.
5. Provide a high degree of usability to leverage for Program Office detailed Specialty Engineering planning, process development and SEDs execution.

6. Provide a low risk and cost effective path toward mission success.

To capture these attributes, the SEDs framework is made up of the following parts:

1. Applicable governance, standards, and guidance.
2. Specialty Engineers' contributions within the acquisition life cycle framework for SMC Specialty Engineering.
3. Specialty Engineers' contributions within the engineering life cycle framework for SMC Specialty Engineering.
4. Specialty Engineers' contributions to program and project management.

How to use this SED Framework

This SED framework describes necessary tasks and products, the policy from which they are derived, their relationship to the engineering, acquisition, and program management frameworks, and the engineering details one should consider in working towards effective and efficient integrated engineering. The importance of this document is not only to the government, but also to the providers (contractors).

Program and Project Managers

If you are a program or project manager, you should be familiar with all system and specialty engineering major events, activities and products that apply to your program or project including those that fall within the purview of the engineering directorate. With the assistance of the Chief Engineer or Lead Systems Engineer, use this SED framework to:

1. Determine which SEDs apply to your program.
2. Assist the systems engineering organization to scope the engineering work to be accomplished, determine the resources required, provide the detailed and integrated planning and scheduling, staff, and execute all activities in an integrated fashion.
3. Ensure the detailed planning is sufficiently integrated into the integrated planning and scheduling.
4. Ensure the engineering control activities are coupled to the program monitoring and control activities.
5. Ensure the engineering contributions are sufficiently provided to support the acquisition activities and products.

Chief Engineer

1. Read through this entire SED framework and support the Program or Project Manager to determine which SEDs apply to your program.
2. Ensure the program organization is structured to execute the applicable engineering activities described in this SED framework.
3. Determine and ensure development and management of technical and engineering Operating Instructions (IOs = processes) to perform the engineering tasks described herein and other relevant engineering tasks that apply to the program.
4. Monitor the overall effectiveness and progress of program technical efforts.
5. Assessment of the contractors' capability to meet the program technical requirements.

Lead Systems Engineer and Systems Engineering Staff Members

Systems Engineers must orchestrate all Specialty Engineers' activities and products to ensure effective and timely integration of the disciplines through the full system life cycle. As illustrated in Figure 1 there are significant interrelationships between the SEDs that require cross-discipline interactions, integration of activities, and sharing of engineering products. This matrix, along with the discussions throughout this SED, provides a means to plan and perform effective integration of activities and engineering products.

		Systems Engineering	Test & Evaluation	Software Engineering	Integrated Logistics Support	Design Engineering	Manufacturing & Producibility	Quality Assurance	Reliability & Maintainability	Spectrum Management	Concept Development	Architecting	System Safety Engineering	Acq Sys Protect & Int'l Prog Sec	Survivability	Human Systems Integration	Mass Properties	EMI/EMC	Parts, Materials & Processes	Information Assurance	Netcentric Engineering	Environmental Engineering	Prognostics, Diagnostics, Health
1	Systems Engineering		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
2	Test & Evaluation	X		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
3	Software Engineering	X	X		X	X	X	X	X	X	X	X	X	X	X	X			X	X	X	X	X
4	Integrated Logistics Support	X	X	X		X	X	X	X		X	X	X	X		X			X	X	X	X	X
5	Design Engineering	X	X	X	X		X	X	X	X	X	X	X		X	X	X	X	X	X	X	X	X
6	Manufacturing and Producibility	X	X	X	X	X		X	X		X	X	X	X		X			X	X		X	X
7	Quality Assurance	X	X	X	X	X	X		X				X	X		X		X	X				X
8	Reliability and Maintainability	X	X	X	X	X	X	X		X	X	X	X		X	X	X	X	X	X	X		X
9	Spectrum Management	X	X	X		X			X		X	X			X			X		X		X	
10	Concept Development	X	X	X	X	X	X		X	X		X	X		X	X	X	X	X	X	X	X	X
11	Architecting	X	X	X	X	X	X		X	X	X		X		X	X	X	X	X	X	X	X	X
12	System Safety Engineering	X	X	X	X	X	X	X	X		X	X			X	X	X	X	X			X	X
13	Acq Sys Protection & Int'l Prog Security	X	X	X	X		X	X							X	X		X	X	X	X		
14	Survivability	X	X	X		X			X	X	X	X	X	X		X		X	X	X	X		X
15	Human Systems Integration	X	X	X	X	X	X	X	X		X	X	X	X	X			X	X	X	X	X	X
16	Mass Properties	X	X			X			X		X	X	X						X				
17	EMI/EMC	X	X			X		X	X	X	X	X	X	X	X	X			X	X		X	
18	Parts, Materials & Processes	X	X	X	X	X	X	X	X		X	X	X	X	X	X	X	X		X	X	X	X
19	Information Assurance	X	X	X	X	X	X		X	X	X	X		X	X	X		X	X		X		X
20	Netcentric Engineering	X	X	X	X	X			X		X	X		X	X	X			X	X			X
21	Environmental Engineering	X	X	X	X	X	X			X	X	X	X			X		X	X				
22	Prognostics, Diagnostics, Health Mgt	X	X	X	X	X	X	X	X		X	X	X		X	X			X	X	X		

Figure 1 Interrelationships among SEDs

Systems Engineers must read through and apply this entire SED document to:

1. Support the Program or Project Manager to determine which SEDs apply to the program.
2. Prepare the systems engineering planning and sufficiently integrate into the overall planning and scheduling.
3. Facilitate development of the SEDs detailed planning and ensure integration into the Systems Engineering Plan (SEP) and program integrated planning and scheduling.
4. Ensure the engineering control activities are fully supported by the specialty engineering disciplines and are coupled to the program monitoring and control activities.
5. Ensure all specialty and systems engineering contributions are timely, adequate, consistent, and compliant to support the engineering, acquisition, and management activities and products.

Specialty Engineers

Specialty Engineers must read, understand and apply the information contained herein to plan and execute their SED. Specialty Engineers must also read and understand all other related SEDs. (Figure 1 identifies the related SEDs.) Each Specialty Engineer also determines which adjunct SED activities they must contribute to or leverage off of then plan and perform to support the Program Office's objective for effective integrated engineering.

Specialty Engineers also use this SED framework along with available SMC instructions and guidance to:

1. Prepare the specialty engineering planning and sufficiently integrate into the SEP and integrated program planning and scheduling.
2. Ensure all specialty engineering contributions are timely, adequate, consistent, and compliant to support systems engineering and adjunct specialty engineering activities.
3. Support the engineering control activities and program monitoring and control activities.
4. Ensure all specialty engineering contributions are sufficiently provided to support the acquisition activities and products.

The SED framework is first presented for systems engineering. The systems engineering framework represents the standard framework that is applied to each SED albeit expanded to capture each SED unique contribution. The next section presents the SMC SEDs framework as applied to the systems engineering discipline. The Appendices provide the applied framework for each SED typically performed on an SMC program.

Life Cycle Systems Engineering – Overarching Engineering

The Systems Engineer (SE) has the responsibility to perform the overarching engineering management and control functions. The Systems Engineer plans and executes the combined engineering efforts in an integrated and effective manner to ensure that each SED contribution is timely, adequate, consistent, and compliant. Hence, the Systems Engineer prescribes and manages the SMC Program's engineering management and technical controls processes.

Systems Engineering is also considered a SED since this discipline includes specific engineering functions: requirements analyses, interface analyses, functional analyses, technical solutions trades, systems studies, and system element allocations, as well as the integration, verification, and validation planning and execution.

Applicable governance, standards, and guidance

Policy, directives, and instructions that mandate systems engineering related requirements are many. Table 2 identifies the significant governance, standards, and guidance which generally require SMC compliance.

Table 2 Governance, standards, and guidance that shape the Systems Engineering discipline

Document No	Governance Title	Issue
DoDI 5000.02	Operation of the Defense Acquisition System	08 Dec 08
CJCSM 3170.01	Operation of the Joint Capabilities Integration and Development System	24 Jun 03
AFI 10-601	Capabilities Based Requirements Development	30 Jul 04
AFI 21-108	Maintenance Management of Space Systems	25 Jul 94
AFI 63-101	Acquisition and Sustainment Life Cycle Management	22 Mar 11
AFI 63-01	Operations of Capabilities Based Acquisition System	29 Jul 05
AFI 63-1201	Life Cycle Systems Engineering	23 Jul 07
SMC Sup AFI 63-1201	Life Cycle Systems Engineering	Draft
SMC Process Directives	Manage Mission Assurance; Develop System & Technology Req'ts; Establish & Manage Eng Baseline; V&V the System Baseline	
Document No	**Standards Title**	**Issue**
SMC-S-001	Systems Engineering Requirements & Products	12 July 10
Document No	**Guidance Title**	**Issue**
SMC-G-001	Systems Engineering Implementation Guide	17 Apr 09
SMC SE HDBK	SMC Systems Engineering Primer and Handbook	29 Apr 05
CPATS	Critical Process Assessment Tool – Systems Engineering	14 Aug 98
DAG-DAU	Defense Acquisition Guide Chapter 4 SE	
	http://www.acq.osd.mil/se/pg/index.html	

Systems engineering practices are critical to acquisition and eventually mission success. Requirements for a systems engineering program are delineated in SMC-S-001, *Systems Engineering Requirements and Products*. This standard generally applies to all SMC acquisitions.

Systems Engineers' Contributions to the Acquisition Life Cycle Framework

The DoD acquisition life cycle is defined by DoDI 5000.02. Systems engineering contributions over this life cycle are best represented within the phase of acquisition. Figure 2 provides the acquisition life cycle framework within which Systems Engineers perform as well as the products that Systems Engineers must develop or contribute to their development. This figure along with SMC-G-001 delineate the Program Office SE OPR requirements to perform SE planning, support pre- and post- contract award acquisition activities, and perform SE management and engineering across the system lifecycle. SMC Program Offices establish and implement SE program strategies and objectives consistent with the tenets of appropriate policies, SMC acquisition objectives, and program objectives. The Program Office will then develop, attain approval for, and implement a SEP in accordance with current DoD policy. This planning will be firmly based on these objectives, strategies, DoD mandates, and instructions. An effective SE program supports all of the major acquisition activities through the full system life cycle. The SEP is executed concurrently with a broad based OI that documents the process to perform, control, and integrate all Systems Engineering activities for each phase of acquisition. The SMC Program Office SEP and OI will also be based upon the appropriate program-approved life cycle.

1. **Materiel Solution Analysis (MSA).** During this phase SE provides inputs to and supports all program acquisition activities to include the development and preparation of a cost model based on anticipated technical solutions, solicitation/RFP development for Contractor studies, and proposal evaluation activities. The SE also contributes to the development of the MSA Phase acquisition products.

MSA Phase – SMC Acquisition Products
PMD
TDS, DMS, TES
LC Cost Estimate
RFP
PPP, APB, CCA
SEP, LCMP

2. **Technology Development (TD).** The SE provides inputs to and supports all program acquisition activities to include updates to the TES and inputs to the ASP, TDS, and development of the TEMP. The SE provides inputs to the CDD and updates to the cost model; development of the Cost Analysis Requirements Description (CARD); and solicitation/RFP development and proposal evaluation activities. The SE assists in the preparation of contract requirements such as advanced technology demonstrations; prototyping, and developmental / qualification testing to meet and Program Office objectives and requirements. The SE also contributes to the development and updates to the TD Phase acquisition products and assesses the effectiveness of the Contractor SE efforts.

TD Phase – SMC Acquisition Products
ASP, TDS, DMS
SEP, LCMP, APB
LC Cost Estimate Update / CARD Development
RFP: SE objectives in SOO; PWS, CDRLs; SMC and Program standards - tailored
SSP: evaluation criteria for SE

3. **Engineering & Manufacturing Development (EMD).** The T&E Engineer provides inputs to and supports all program acquisition activities to include updates to the ASP, TDS and DMS; inputs to the cost model and CARD to reflect the engineering resources required; development of the APB. SE supports the solicitation/RFP development and proposal evaluation activities which include providing the technical inputs including technical requirements, compliance standards, engineering approaches, incentives, and warranty programs to meet program objectives. SE also contributes to the development and updates to the EMD Phase acquisition products.

EMD Phase - SMC Acquisition Products
Updates to ASP, TDS, DMS
SEP, LCMP, APB
LC Cost Estimate Update / CARD Development
RFP: SE objectives in SOO; PWS, CDRLs; SMC and Program standards - tailored
SSP: evaluation criteria for SE

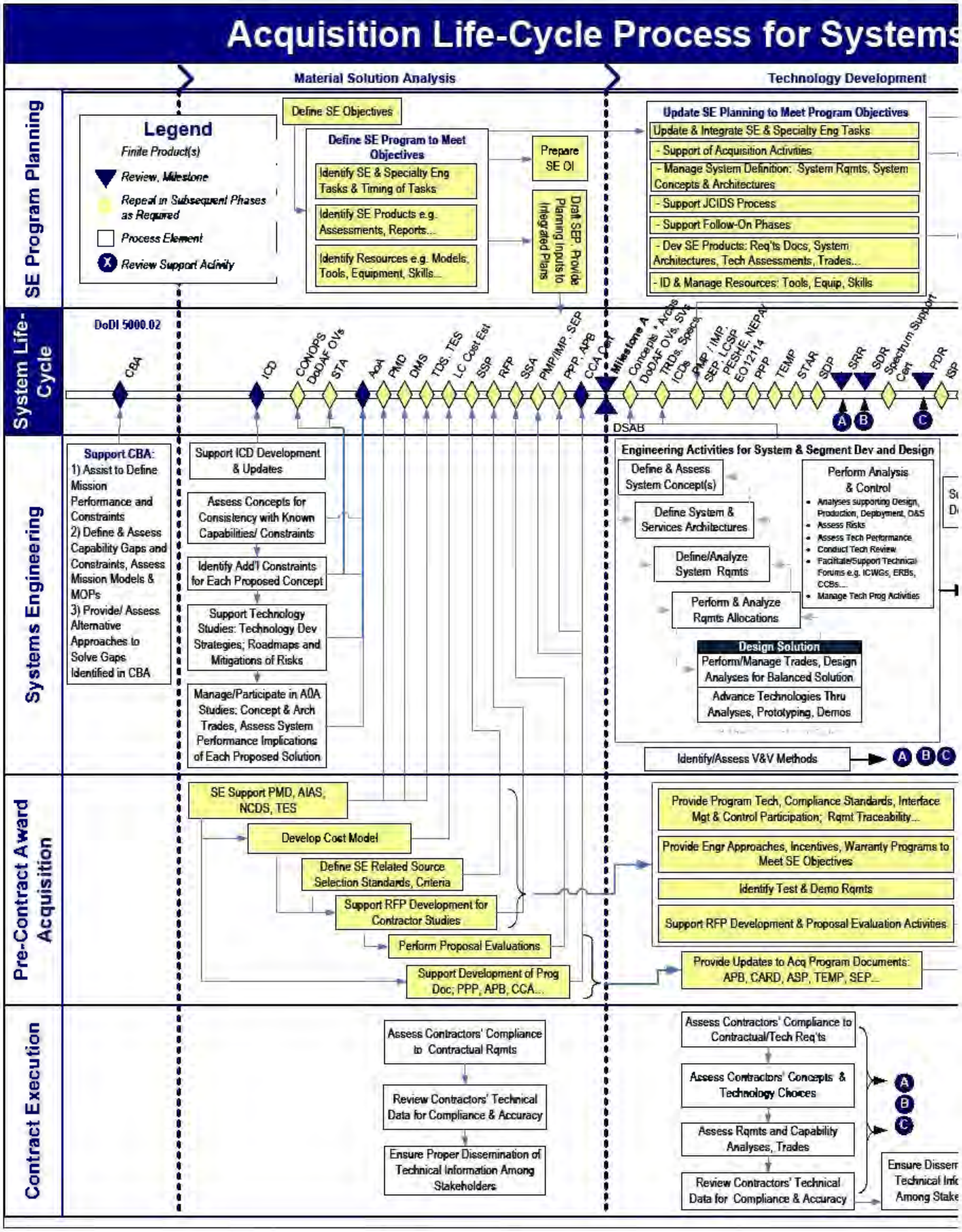
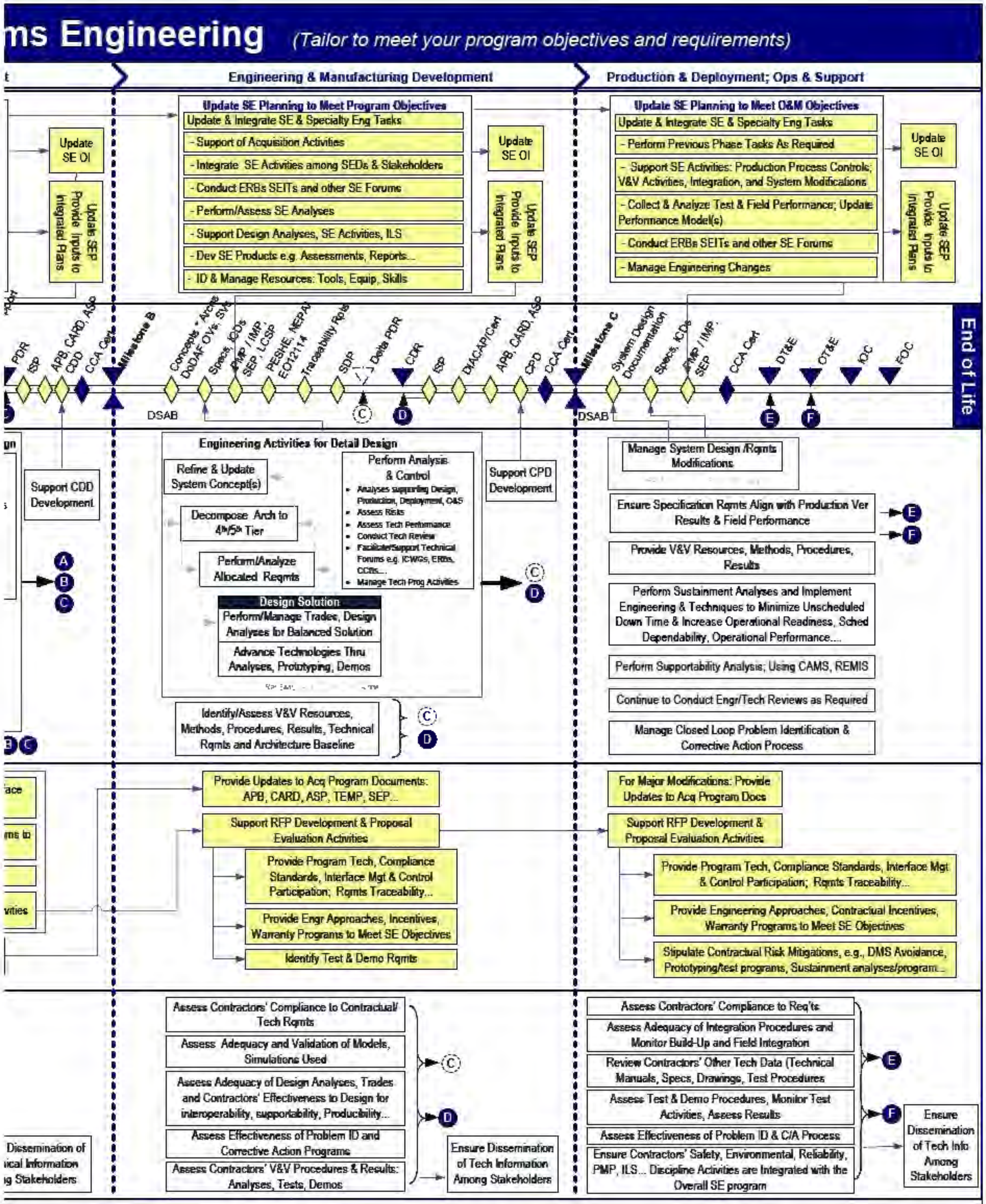


Figure 2 Acquisition life cycle process for SMC Systems Engineering



ms Engineering (Tailor to meet your program objectives and requirements)
Engineering & Manufacturing Development
Production & Deployment; Ops & Support
Update SE OI
Update SEP Provide Inputs to Integrated Plans
Update SE Planning to Meet Program Objectives
Update & Integrate SE & Specialty Eng Tasks
- Support of Acquisition Activities
- Integrate SE Activities among SEDs & Stakeholders
- Conduct ERBs SEITs and other SE Forums
- Perform/Assess SE Analyses
- Support Design Analyses, SE Activities, ILS
- Dev SE Products e.g. Assessments, Reports...
- ID & Manage Resources: Tools, Equip, Skills
Update SE Planning to Meet O&M Objectives
Update & Integrate SE & Specialty Eng Tasks
- Perform Previous Phase Tasks As Required
- Support SE Activities: Production Process Controls; V&V Activities, Integration, and System Modifications
- Collect & Analyze Test & Field Performance; Update Performance Model(s)
- Conduct ERBs SEITs and other SE Forums
- Manage Engineering Changes
End of Life
PDR
ISP
APB, CARD, ASP
CDD
CCA Cert
Milestone B
Concepts • Archs
DoDAF OVs, SVs
Specs, ICDs
PMP / IMP
SEP, LCSP
PESHE, NEPA/EO12114
Traceability Rqts
SDP
Delta PDR
CDR
ISP
DIACAP/Cert
APB, CARD, ASP
CPD
CCA Cert
Milestone C
System Design Documentation
Specs, ICDs
PMP / IMP, SEP
CCA Cert
DT&E
OT&E
IOC
FOC
DSAB
DSAB
Support CDD Development
Engineering Activities for Detail Design
Refine & Update System Concept(s)
Decompose Arch to 4th/5th Tier
Perform/Analyze Allocated Reqmts
Perform Analysis & Control
Analyses supporting Design, Production, Deployment, O&S
Assess Risks
Assess Tech Performance
Conduct Tech Review
Facilitate/Support Technical Forums e.g. ICWGs, ERBs, CCBs...
Manage Tech Prog Activities
Design Solution
Perform/Manage Trades, Design Analyses for Balanced Solution
Advance Technologies Thru Analyses, Prototyping, Demos
Support CPD Development
Identify/Assess V&V Resources, Methods, Procedures, Results, Technical Rqmts and Architecture Baseline
Manage System Design /Rqmts Modifications
Ensure Specification Rqmts Align with Production Ver Results & Field Performance
Provide V&V Resources, Methods, Procedures, Results
Perform Sustainment Analyses and Implement Engineering & Techniques to Minimize Unscheduled Down Time & Increase Operational Readiness, Sched Dependability, Operational Performance....
Perform Supportability Analysis; Using CAMS, REMIS
Continue to Conduct Engr/Tech Reviews as Required
Manage Closed Loop Problem Identification & Corrective Action Process
Provide Updates to Acq Program Documents: APB, CARD, ASP, TEMP, SEP...
Support RFP Development & Proposal Evaluation Activities
Provide Program Tech, Compliance Standards, Interface Mgt & Control Participation; Rqmts Traceability...
Provide Engr Approaches, Incentives, Warranty Programs to Meet SE Objectives
Identify Test & Demo Rqmts
For Major Modifications: Provide Updates to Acq Program Docs
Support RFP Development & Proposal Evaluation Activities
Provide Program Tech, Compliance Standards, Interface Mgt & Control Participation; Rqmts Traceability...
Provide Engineering Approaches, Contractual Incentives, Warranty Programs to Meet SE Objectives
Stipulate Contractual Risk Mitigations, e.g., DMS Avoidance, Prototyping/test programs, Sustainment analyses/program...
Assess Contractors' Compliance to Contractual/Tech Rqmts
Assess Adequacy and Validation of Models, Simulations Used
Assess Adequacy of Design Analyses, Trades and Contractors' Effectiveness to Design for interoperability, supportability, Producibility...
Assess Effectiveness of Problem ID and Corrective Action Programs
Assess Contractors' V&V Procedures & Results: Analyses, Tests, Demos
Ensure Dissemination of Tech Information Among Stakeholders
Dissemination of ...ical Information ...g Stakeholders
Assess Contractors' Compliance to Req'ts
Assess Adequacy of Integration Procedures and Monitor Build-Up and Field Integration
Review Contractors' Other Tech Data (Technical Manuals, Specs, Drawings, Test Procedures
Assess Test & Demo Procedures, Monitor Test Activities, Assess Results
Assess Effectiveness of Problem ID & C/A Process
Ensure Contractors' Safety, Environmental, Reliability, PMP, ILS... Discipline Activities are Integrated with the Overall SE program
Ensure Dissemination of Tech Info Among Stakeholders

4. **Production & Deployment (P&D), Operations & Support (O&S).** SE provides inputs to and supports all program acquisition activities to include updates to the acquisition strategy and updates to the cost model to reflect the actual technical solutions determined and updates to the CARD. SE supports the solicitation/RFP development and proposal evaluation activities.

P&D/O&S Phases - SMC Acquisition Products
Updates to ASP, TDS, TEMP, SEP, LCMP
RFP: objectives in SOO; PWS, CDRLs; SMC- SMC and Program Standards - tailored
Detailed T&E planning, SEP, LCMP, CARD updates

Systems Engineers' Contributions to the Engineering Life Cycle Framework

Systems Engineers manage the engineering process and activities depicted in Figure 3. The characteristics of this process are defined in the *SMC Systems Engineering Primer and Handbook* and the *SMC Systems Engineering Standard* SMC-S-001. In summary, this engineering life-cycle framework:

- Provides engineering activities over a system or product life cycle
- Aligns activities to an evolving technical baseline
- Aligns both the activities and technical baseline with required technical review gates
- Provides an overarching engineering management and control function as defined within the *Analysis & Control* process

This framework also inherently captures the SE SED -- specific engineering functions -- requirements analyses, interface analyses, functional analyses, technical solutions trades, requirements and system element allocations, as well as the integration and verification and validation planning and execution.

The responsibility to orchestrate the engineering functions and manage technical information typically resides within the systems engineering organization. In performing the management and control function, the SE effectively integrates all engineering functions through the full system life cycle. The SE ensures technical information advances through systematic control, collaboration and sharing across the organization. The approach to concurrently perform these engineering functions and manage information is delineated in the *SMC Systems Engineering Primer and Handbook*.

Tools Selection and Use

Effectiveness and efficiencies are also gained by selecting and using an optimal mix of engineering tools. Generally, the SE leads the study to determine the selection and use of engineering tools. Each SED supports this tool determination ensuring their unique tool requirements are considered and ensuring timely exchanges of technical information among the tools and their respective databases. Systems Engineers typically require a suite of tools to support the functions illustrated here.

SE Functions Requiring Tools
Architecture Development
Requirements Development & Management
Requirements Analyses
Modeling & Simulations
Verification & Validation

Engineering Activities and Products over the Life Cycle

The following subsections summarize SE contributions to engineering activities and technical products by DOD acquisition phase. For detailed activities, requirements and products refer to the SMC publications SMC-S-001, SMC-G-001.

1. **Materiel Solution Analysis.** During this phase the SE provides inputs to and supports the Capabilities Based Assessment (CBA) process and the Joint Capabilities Integration and Development System (JCIDS) process. The SE assists the operating command to develop the operational concept(s), prepare the ICD, STAR, operational architectural products (OVs, CVs), support AoA studies, and support threat assessments. The SE develops and contributes to

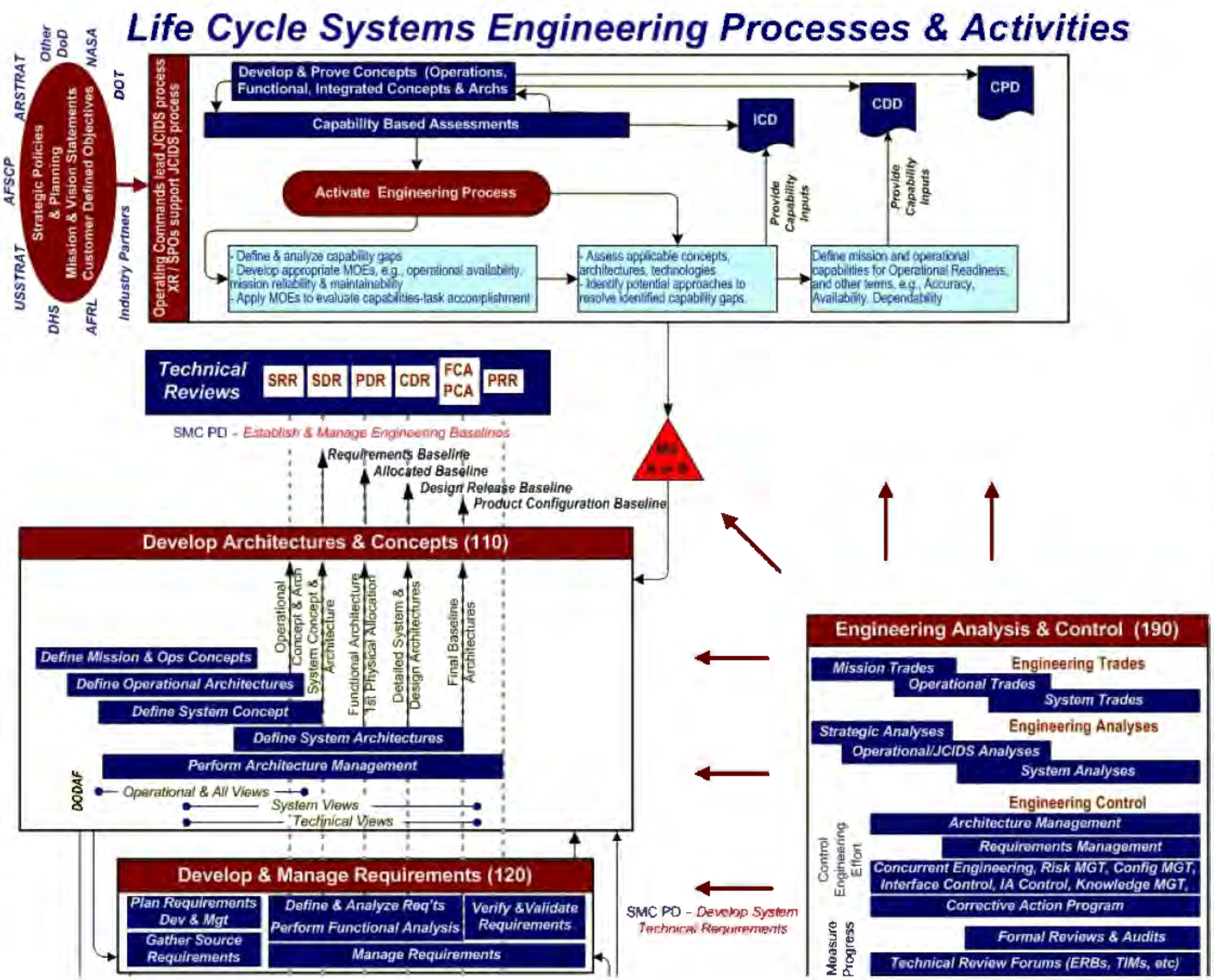
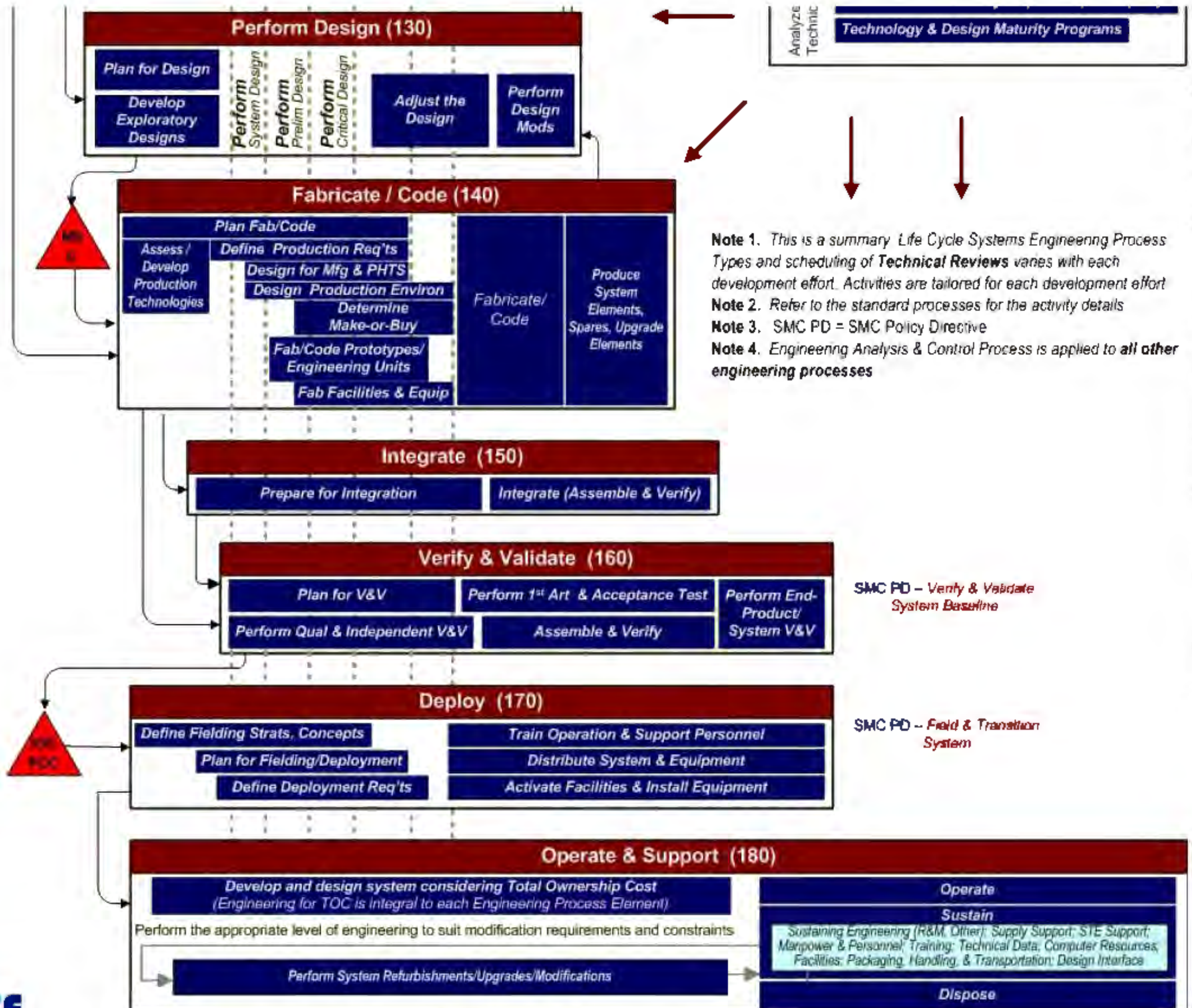


Figure 3 Typical SMC engineering processes and activities over a system lifecycle



Note 1. *This is a summary Life Cycle Systems Engineering Process Types and scheduling of* ***Technical Reviews*** *varies with each development effort. Activities are tailored for each development effort*

Note 2. *Refer to the standard processes for the activity details*

Note 3. SMC PD = SMC Policy Directive

Note 4. *Engineering Analysis & Control Process is applied to* ***all other engineering processes***

development of the MSA Phase technical products. SE leads in the development of or supports the technical strategy development, e.g., TES, ASP, TDS, and DMS. The SE manages the system concept development activities: inputs and factors for concept, architecture, technology studies and demonstrations, and trades. The SE ensures the development of technology roadmaps and identification and mitigation of technical and program risks.

MSA Phase – Technical Products Required	
SMC SE Technical Products	**SE Contributions to Other Organizations' Products**
Technology Sol'ns Studies	Operational Concepts
System Concepts	Analysis of Alternatives (AoA) Studies
System Tech Req'ts (draft)	Initial Capabilities Doc (ICD) Development, STAR
	DoDAF CVs, OVs

2. **Technology Development.** During this phase the SE continues to provide inputs to and supports the JCIDS process. The SE also initiates the set of engineering activities highlighted within the box titled *Engineering Activities for System & Segment Development & Design* Figure 2 to commence system definition and development. SE develops and contributes to development of the TD Phase technical products.

TD Phase – Technical Products Required	
SMC SE Technical Products	**SE Contributions to Other Organizations' Products**
System & Arch Concepts	Operational Concepts
Technology & Technical Sol'n Studies, and Trades	Operational Assessments, STAR, AoA
Architectures: System & Service DODAF Views; ISP	Capabilities Development Doc (CDD)
System Tech Req'ts, TRD, SRD, Specs, ICDs, Standards	DoDAF CVs, OVs

3. **Engineering & Manufacturing Development.** SE continues to provide inputs to and support the JCIDS process. The SE also initiates the expanded set of engineering activities highlighted within the box titled *Engineering Activities for Detailed Design* Figure 2 to commence detailed systems definition and development. SE develops and contributes to the development of the EMD Phase technical products.

EMD Phase – Technical Products Required	
SMC SE Technical Products	**SE Contributions to Other Organizations' Products**
Update System Concept	Operational Concepts
Technical Studies/ Trades	Operational Assessments
System Tech Req'ts, TRD, SRD, Spec, ICDs	Capabilities Production Doc (CPD)
SVs, SvcVs, TVs, ISP	DoDAF CVs, OVs
Engineering Analyses Rpts	
V&V reports	

4. **Production & Deployment, Operations & Support.** SE continues to provide inputs to and supports the JCIDS process. SE develops and contributes to the development of the P&D / O&S technical products.

P&D/O&S Phases – Technical Products Required	
SMC SE Technical Products	**SE Contributions to Other Organizations' Products**
System Design Docs	Supportability Analyses Rpt
System Production Docs	Operational Assessments
Engineering Analyses Rpts (OT&E results; performance reports; field test reports)	Transition & Fielding Docs
Tech Baseline Engineering Change Products	
Analyses of production quality reports and test reports	

Systems Engineers' Contributions to Program and Project Management

Each SMC program defines their business model and business and technical approach structure based primarily on their program objectives, program and technical challenges, organizational structure, as well as program and engineering planning (SEP plus detailed engineering planning). Execution of the planning is typically defined through Program Office Operating Instructions (OIs). The Program Control activities are also defined within the processes (OIs) or as separate processes. SE provides full support to define the program objectives, establish a business model, develop program planning and schedules, and define and implement program processes. SE must ensure the technical components of the program are appropriately represented in the program plans, program schedules, work breakdown schedules, and cost estimates.

SE also ensures the timely reporting and integrity of the technical performance and developmental progress. SE shares in the risk management responsibilities to identify, assess, and propose mitigating actions of technical risks. SE supports the program manager's problem identification, resolution, and decision making processes.

The SMC Systems Engineering Primer & Handbook describes the role-up and relationships of the engineering detailed plans, schedules, and WBS, as well as the integration of SE with program and project management. SE develops and contributes to the development of the program management products identified in the table to the right.

SE Contributes to the development & updates to SMC Program Management Products
PMD
IMP, IMS, WBS
Decision-making & problem solving inputs
Technical progression and issues reporting
Life-Cycle Cost Estimate (CARDs)
Processes (OIs)
Risk Management Inputs

Appendix A – Test and Evaluation Engineering

Test and Evaluation (T&E) is a pervasive Program Office discipline that is essential for the successful acquisition of space, missile, and ground systems that ultimately leads toward full verification of the technical baseline of the system, allocated, and design requirements and validation of the operational capabilities. The SMC Program Office T&E Engineer stand-ups and executes the T&E program. The T&E Engineer initially develops the SMC Program's test strategy in the Materiel Solution Analysis (MSA) phase and initiates and implements the test planning beginning in the Technology Development (TD) and succeeding phases of acquisition. The T&E Engineer strategizes, plans, coordinates, and manages the T&E program and ensures progress through technology demonstrations, prototyping, qualification testing, production testing, integration testing, pre and post launch systems check-out, and operational testing through the development, production, operation, and sustainment of a system or product.

Throughout the program acquisition life-cycle, the T&E Engineer ensures evolving technologies and design solutions meet system and design specifications and the final design meets operational requirements and constraints. The T&E Engineer organizes and integrates T&E activities, resources, and information within statutory and regulatory guidelines and sound engineering principles. The T&E Engineer ensures the baseline test requirements are appropriately established, resources are available, and the events are incorporated in the contractors Integrated Master Schedule (IMS) and government master schedules. The T&E Engineer strives for the identification and elimination of inherent or latent defects, process (e.g. workmanship), and procedural deficiencies to ensure a high level of confidence in the progression of the system development efforts to meet the intended reliability growth targets, performance requirements, and Total Ownership Cost (TOC) targets. The T&E Engineer collaborates with the Program Office Systems Engineering organization and the acquisition community, and provides the evaluation results including deficiency and risk discovery and remedies.

The T&E Engineer, Air Force Operational Test and Evaluation Center (AFOTEC) (or the lead operational test organization) and stakeholders prepare the Integrated Test Team (ITT) charter and conduct the ITT through all program phases. The T&E Engineer assures that all stakeholder requirements are satisfied by working with the ITT as a cross-functional team.

Applicable governance, standards, and guidance

Policy, directives, and instructions that govern T&E are included in a wide range of mandates including those providing requirements for acquisition, systems engineering, information assurance, software development, safety, and others. Table 3 below identifies significant governance and standards which require SMC compliance for T&E as well as implementation guidance.

DoDD 5000.01 directs that T&E is integrated throughout the defense acquisition process and that "test and evaluation shall be structured to provide essential information to decision-makers, assess attainment of technical performance parameters, and determine whether systems are operationally effective, suitable, survivable, and safe for intended use. The conduct of test and evaluation, integrated with modeling and simulation, shall facilitate learning, assess technology maturity and interoperability, facilitate integration into fielded forces, and confirm performance against documented capability needs and adversary capabilities as described in the system threat assessment."

DoDI 5000.02 Enclosure 6, *Integrated T&E*, details specific test and evaluation procedures. CJCSI 3170.01G instructs that KPPs must be testable to enable feedback from test and evaluation efforts to the requirements process.

AFI 99-103 provides the primary T&E governance to implement DoDD 5000.01 and DoDI 5000.02. The standards listed in the table below provide typical requirements and guidelines for T&E. The SMC design standards generally provide T&E requirements specific to the technology, Line-Replaceable Unit (LRU) type, and device. Hence, the more detailed test requirements are largely determined during the system development and design process.

Table 3 Governance, standards, and guidance that shape the Test and Evaluation Engineering discipline

Document No	Governance Title	Issue
DoDD 5000.01	Defense Acquisition System	20 Nov 07
DoDI 5000.02	Operation of the Defense Acquisition System	08 Dec 08
CJCSI 3170.01G	Joint Capabilities Integration and Development System	1 Mar 09
AFPD 99-1	Test & Evaluation Process	22 Jul 93
AFI 99-103	Capability-Based Test & Evaluation	20 Mar 09
AFI 10-601	Operational Capability Requirements Development	12 Jul 10
AFI 63-101	Acquisition And Sustainment Life Cycle Management	22 Mar 11
Document No	**Standards Title**	**Issue**
SMC-S-004	Independent Structural Loads Analysis	13 Jun 08
SMC-S-005	Space Systems – Flight Pressurized Systems	03 Jun 09
SMC-S-006	Solid Rocket Motor Case Design And Test	13 Jun 08
SMC-S-007	Space Battery	13 Jun 08
SMC-S-008	Electromagnetic Compatibility Requirements For Space Equipment And Systems	13 Jun 08
SMC-S-009	Parts, Materials, and Processes Control Program for Space & Launch Vehicles	12 Jan 09
SMC-S-010	Technical Requirements for Electronic Parts, Materials, and Processes for Space and Launch Vehicles	12 Jan 09
SMC-S-011	Parts, Materials, & Processes Control Program for Expendable Launch Vehicles	13 Jun 08
SMC-S-012	Software Development For Space Systems	13 Jun 08
SMC-S-013	Reliability Program For Space Systems	13 Jun 08
SMC-S-016	Test Requirements For Launch, Upper-Stage & Space Vehicles	13 Jun 08
SMC-S-017	Lithium-Ion Battery For Spacecraft Applications	13 Jun 08
SMC-S-018	Lithium-Ion Battery For Launch Vehicle Applications	13 Jun 08
SMC-S-020	Technical Requirements For Wiring Harness, Space Vehicle	03 Jun 09
MIL-STD-461F	Electromagnetic Emissions and Susceptibility, Requirements for the Control of Electromagnetic Interference	10 Dec 07
MIL-STD-810G	Environmental Engineering Considerations And Laboratory Tests	31 Oct 08
MIL-STD-1833	Test Requirements For Ground Equipment And Associated Computer Software Supporting Space Vehicles	13 Nov 89
MIL-STD-1542B	Electromagnetic Compatibility And Grounding Requirements For Space System Facilities	15Nov 91
AIAA S-080-1998	Space Systems-Metallic Pressure Vessels, Pressurized Structures and Pressure Components	1 Jan 99
AIAA S-081-2000	Space Systems-Composite Overwrapped Pressure Vessels	1 Jan 01
AIAA S-110-2005	Space Systems-Structures, Structural Components and Structural Assembly	12 Jul 05
AIAA S-114-2005	Moving Mechanical Assemblies for Space and Launch Vehicles	30 Jun 05
AIAA S-113-2005	Criteria for Explosive Systems & Devices Used on Space Vehicles	

AIAA S-111-2005	Qualification and Quality Standards for Space-Qualified Solar Cells	26 Sept 05
AIAA S-112-2005	Qualification and Quality Req'ts for Space-Qualified Solar Panels	26 Sept 05
Document No	**Guidance Title**	**Issue**
MIL-HDBK-340A, V III	Test Req'ts for Launch, Upper Stage and Space Vehicles: Application Guidelines	01 Apr 99
AFSPCMAN 91-710	Range Safety User Requirements Manual	1 Jul 04
DAG	DAG, Chapter 9: Test & Evaluation (T&E)	https://dag.dau.mil/

T&E Engineers' Contributions to the Acquisition Life Cycle Framework

The DoD acquisition life cycle is defined by DoDI 5000.02. The T&E Engineer contributions over this life cycle are best represented within the acquisition phase. Figure 4 provides the acquisition life cycle framework within which T&E Engineers perform as well as the products that they must develop or contribute to the system development. This figure along with the governance sited above such as AFI 99-103, *Capability-Based Test & Evaluation* provide the requirements to perform T&E planning, stand-up and conduct the ITT, support pre and post contract award acquisition activities, and perform T&E management and engineering across the system lifecycle. The SMC Program Office establishes and implements T&E program strategies and objectives consistent with SMC acquisition and program objectives. From the T&E program strategies the Program Office develops, approves, and incorporates detailed T&E planning into the Test and Evaluation Master Plan (TEMP), Systems Engineering Plan (SEP) and higher level integrated planning (e.g., Integrated Master Plan, Life-Cycle Master Plan, Life-Cycle Sustainment Plan) in accordance with DoD policy and Program Office practices. Hence, T&E planning is firmly based on program objectives and technical requirements, strategies, and DoD mandates and instructions.

An effective T&E program supports all of the major acquisition activities through the full system life cycle. The planning sufficiently defines the T&E program to achieve the T&E and overall program objectives/goals and requirements: specifies tasks and functions to be performed, timing of tasks, resources required, products to be developed, and forms the basis for the development of the program T&E Operating Instruction (OI). The T&E planning and OI are then reflected appropriately in the WBS, IMS, and other program documents that address T&E related elements. The T&E planning is executed concurrently with the Program Office OI that documents the process to perform, control, and integrate all T&E activities for each phase of acquisition.

The SMC Program Office T&E planning (usually contained in the SEP and the detailed T&E program planning) and OI are to be based upon the appropriate program-approved life cycle. SMC Program Offices establish and implement T&E program strategies and objectives consistent with the tenets of appropriate policies, SMC acquisition objectives, and program objectives.

1. **Materiel Solution Analysis.** During this phase the T&E Engineer with community involvement formulates the T&E Strategy (TES). Technology Development Strategy (TDS), and provides inputs to and supports acquisition activities to include development of acquisition strategy, technology development strategy, and data strategies. The T&E Engineer provides inputs to the cost estimates, solicitation/ Request for Proposal (RFP) development for Contractor studies, and proposal evaluation activities. The T&E Engineer also contributes to the development of the MSA Phase acquisition products.

MSA Phase – SMC Acquisition Products
Inputs ASP, TDS, DMS
Prepare TES
Inputs to SEP, LCMP, CARD
Inputs to LC Cost Estimate
Inputs to APB
RFP: T&E objectives in the SOO; T&E tasks in PWS, T&E data products in CDRLs; SMC- T&E standards

2. **Technology Development.** The T&E Engineer provides inputs to and supports all program acquisition activities to include inputs to the Acquisition Strategy and development of the TEMP. The T&E Engineer provides updates to the cost model; development of the Cost Analysis Requirements Description (CARD); and solicitation/RFP development and proposal evaluation activities. The T&E Engineer assists in the preparation of contract requirements such as advanced technology demonstrations; prototyping, and developmental / qualification testing to meet T&E and Program Office objectives and requirements. The T&E Engineer also contributes to the development and updates to the TD Phase acquisition products. The T&E Engineer assesses the effectiveness of the Contractor T&E efforts.

TD Phase – SMC Acquisition Products
Updates to ASP, DMS TEMP preparation
Detailed T&E planning; Inputs to SEP, LCMP
LC Cost Estimate Update / CARD Development
Inputs to APB: T&E objectives & related concept descriptions
RFP: T&E objectives in the SOO; T&E tasks in PWS, T&E data products in CDRLs; SMC- T&E standards - tailored
SSP: evaluation criteria for T&E

3. **Engineering & Manufacturing Development.** The T&E Engineer provides inputs to and supports all program acquisition activities to include updates to the Acquisition Strategy Panel (ASP) and Data Management Strategy (DMS); updates to the TEMP: inputs to the cost model and CARD to reflect the test events and resources required; inputs to the Acquisition Program Baseline (APB).

   T&E strategies are likely integral to the reliability growth strategies as well as strategies to achieve system performance. The strategies now extend to ensure full verification and validation (V&V) of the system design determined through system trades and engineering analyses. The T&E Engineer supports the preparation of contract requirements such as T&E performance work statements; identification and tailoring of the compliance test standards; preparation of the T&E related Contract Data Requirements Lists (CDRLs) for submission of test plans, procedures, reports; government furnished test equipment and facilities; government monitoring of tests. The T&E Engineer also contributes to the development and updates to the EMD Phase acquisition products.

EMD Phase – SMC Acquisition Products
Updates to ASP, DMS
Updates to TEMP
Detailed T&E planning; Inputs to SEP, LCMP
LC Cost Estimate Update / CARD Development
Inputs to CPD
Inputs to APB: T&E objectives & related concept descriptions
RFP: T&E objectives in the SOO; T&E tasks in PWS, T&E data products in CDRLs; SMC- T&E standards - tailored
SSP: evaluation criteria for T&E
Updates to CARD

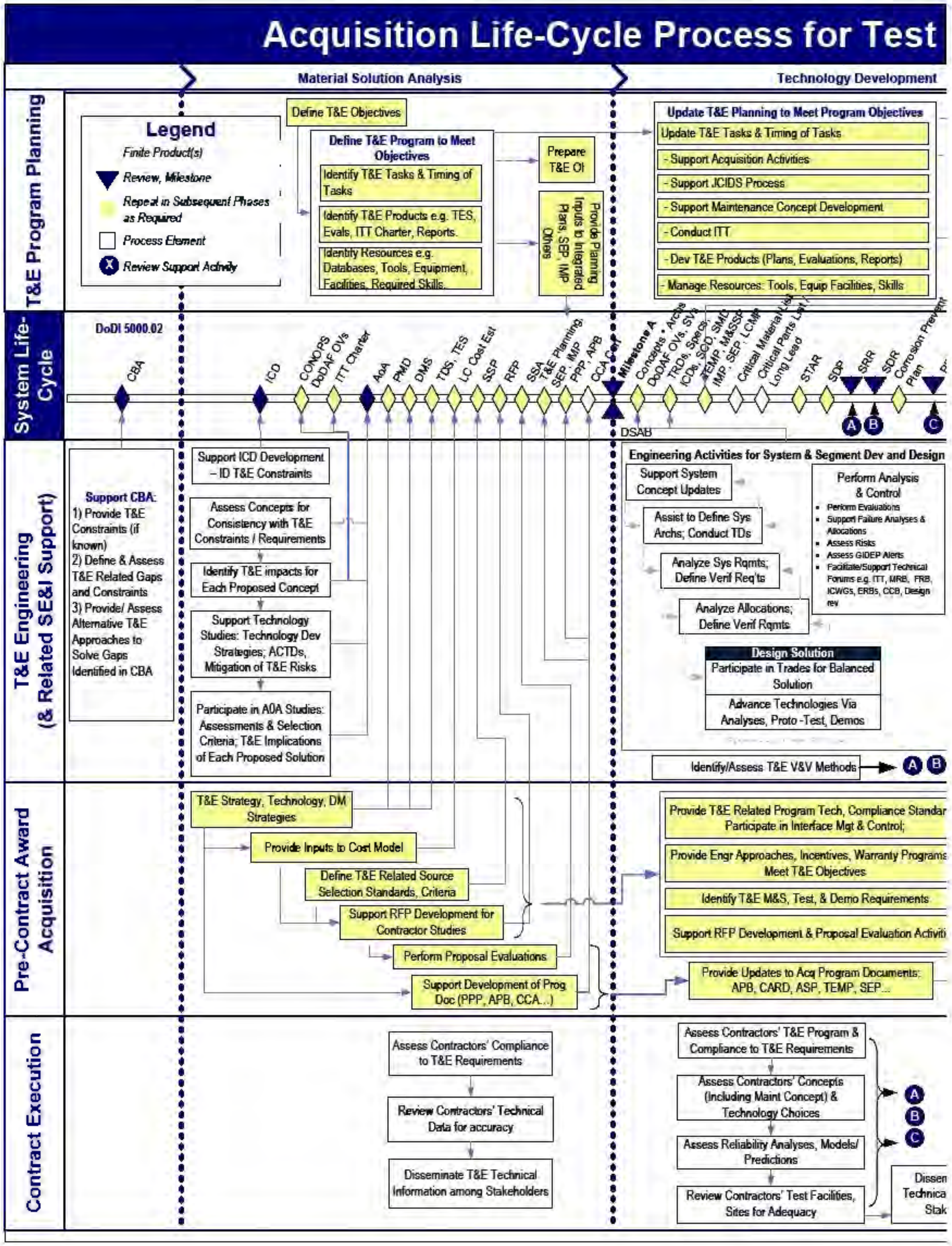
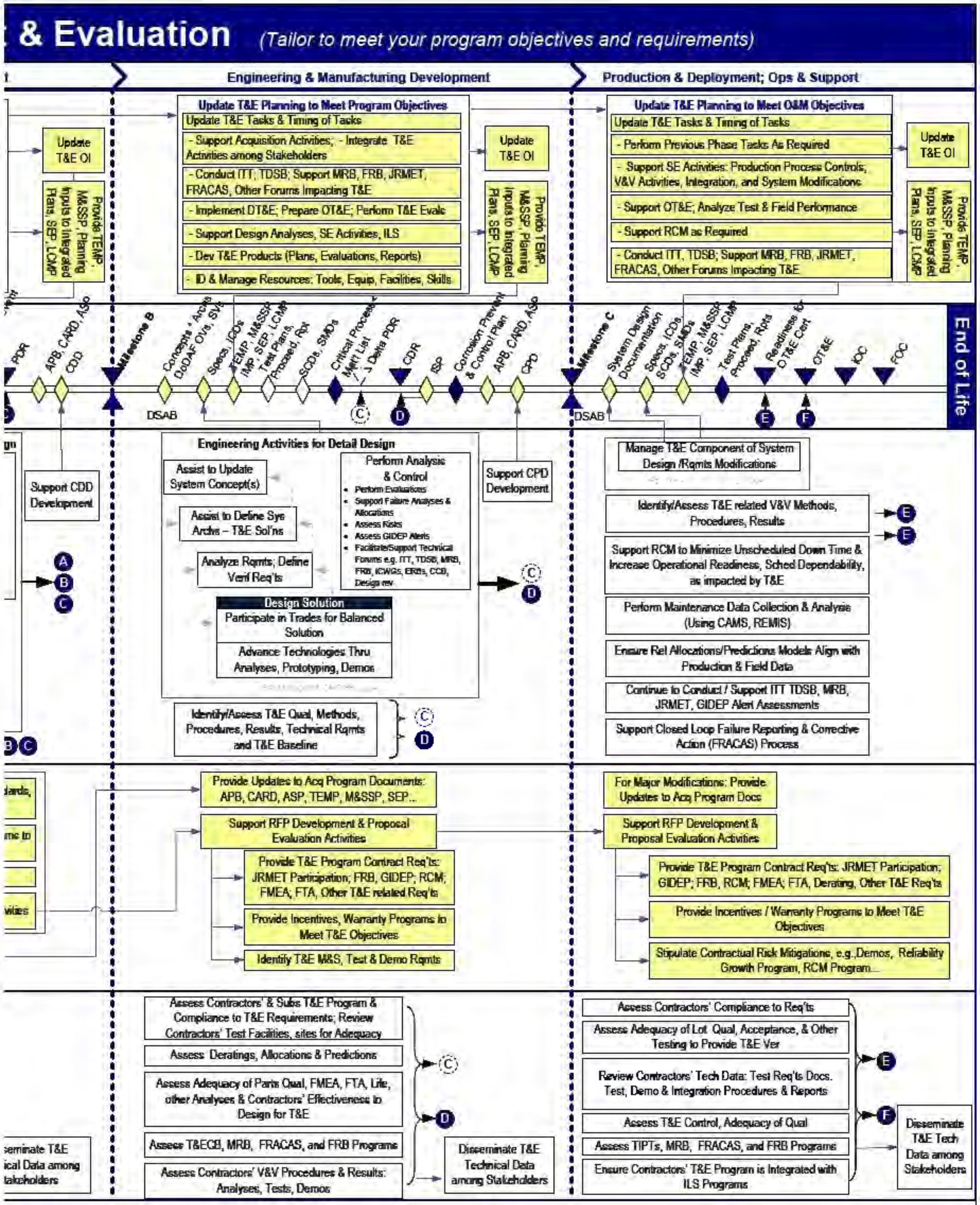


Figure 4 Acquisition life cycle process for SMC Test and Evaluation Engineering


& Evaluation (Tailor to meet your program objectives and requirements)
Engineering & Manufacturing Development
Production & Deployment; Ops & Support
Update T&E Planning to Meet Program Objectives
Update T&E Tasks & Timing of Tasks
- Support Acquisition Activities; - Integrate T&E Activities among Stakeholders
- Conduct ITT, TDSB; Support MRB, FRB, JRMET, FRACAS, Other Forums Impacting T&E
- Implement DT&E; Prepare OT&E; Perform T&E Evals
- Support Design Analyses, SE Activities, ILS
- Dev T&E Products (Plans, Evaluations, Reports)
- ID & Manage Resources: Tools, Equip, Facilities, Skills
Update T&E OI
Provide TEMP, M&SSP, Planning Inputs to Integrated Plans, SEP, LCMP
Update T&E Planning to Meet O&M Objectives
Update T&E Tasks & Timing of Tasks
- Perform Previous Phase Tasks As Required
- Support SE Activities: Production Process Controls; V&V Activities, Integration, and System Modifications
- Support OT&E; Analyze Test & Field Performance
- Support RCM as Required
- Conduct ITT, TDSB; Support MRB, FRB, JRMET, FRACAS, Other Forums Impacting T&E
End of Life
PDR
APB, CARD, ASP
CDD
Milestone B
DSAB
Critical Process / Mat'l List
Delta PDR
CDR
ISP
Corrosion Prevent & Control Plan
APB, CARD, ASP
CPD
Milestone C
System Design Documentation
Specs, ICDs, SCDs, SMDs
TEMP, M&SSP, IMP, SEP, LCMP
Test Plans, Proced, Rpts
Readiness for OT&E Cert
OT&E
IOC
FOC
Support CDD Development
Engineering Activities for Detail Design
Assist to Update System Concept(s)
Assist to Define Sys Archs – T&E Sol'ns
Analyze Rqmts; Define Verif Req'ts
Perform Analysis & Control
Perform Evaluations
Support Failure Analyses & Allocations
Assess Risks
Assess GIDEP Alerts
Facilitate/Support Technical Forums e.g. ITT, TDSB, MRB, FRB, ICWGs, ERBs, CCB, Design rev
Design Solution
Participate in Trades for Balanced Solution
Advance Technologies Thru Analyses, Prototyping, Demos
Support CPD Development
Identify/Assess T&E Qual, Methods, Procedures, Results, Technical Rqmts and T&E Baseline
Manage T&E Component of System Design /Rqmts Modifications
Identify/Assess T&E related V&V Methods, Procedures, Results
Support RCM to Minimize Unscheduled Down Time & Increase Operational Readiness, Sched Dependability, as impacted by T&E
Perform Maintenance Data Collection & Analysis (Using CAMS, REMIS)
Ensure Rel Allocations/Predictions Models Align with Production & Field Data
Continue to Conduct / Support ITT TDSB, MRB, JRMET, GIDEP Alert Assessments
Support Closed Loop Failure Reporting & Corrective Action (FRACAS) Process
Provide Updates to Acq Program Documents: APB, CARD, ASP, TEMP, M&SSP, SEP...
Support RFP Development & Proposal Evaluation Activities
Provide T&E Program Contract Req'ts: JRMET Participation; FRB, GIDEP; RCM; FMEA, FTA, Other T&E related Req'ts
Provide Incentives, Warranty Programs to Meet T&E Objectives
Identify T&E M&S, Test & Demo Rqmts
For Major Modifications: Provide Updates to Acq Program Docs
Support RFP Development & Proposal Evaluation Activities
Provide T&E Program Contract Req'ts: JRMET Participation; GIDEP; FRB, RCM; FMEA; FTA, Derating, Other T&E Req'ts
Provide Incentives / Warranty Programs to Meet T&E Objectives
Stipulate Contractual Risk Mitigations, e.g.,Demos, Reliability Growth Program, RCM Program...
Assess Contractors' & Subs T&E Program & Compliance to T&E Requirements; Review Contractors' Test Facilities, sites for Adequacy
Assess Deratings, Allocations & Predictions
Assess Adequacy of Parts Qual, FMEA, FTA, Life, other Analyses & Contractors' Effectiveness to Design for T&E
Assess T&ECB, MRB, FRACAS, and FRB Programs
Assess Contractors' V&V Procedures & Results: Analyses, Tests, Demos
Disseminate T&E Technical Data among Stakeholders
Assess Contractors' Compliance to Req'ts
Assess Adequacy of Lot Qual, Acceptance, & Other Testing to Provide T&E Ver
Review Contractors' Tech Data: Test Req'ts Docs, Test, Demo & Integration Procedures & Reports
Assess T&E Control, Adequacy of Qual
Assess TIPTs, MRB, FRACAS, and FRB Programs
Ensure Contractors' T&E Program is Integrated with ILS Programs
Disseminate T&E Tech Data among Stakeholders

4. **Production & Deployment, Operations & Support.** The T&E Engineer provides inputs to and supports all program acquisition activities to include updates to the ASP and DMS; updates to the TEMP; inputs to the cost model and CARD to reflect the test resources required; inputs to the APB. The T&E Engineer supports the preparation of contract requirements such as T&E performance work statements; identification and tailoring of the compliance test standards; preparation of the T&E related CDRLs for submission of test plans, procedures, reports; government furnished test equipment and facilities; government monitoring of tests.

P&D / O&S Phase – SMC Acquisition Products
Updates to ASP, TEMP
Detailed T&E planning; Inputs to SEP, LCMP
RFP: T&E objectives in the SOO; T&E tasks in PWS, T&E data products in CDRLs; SMC- T&E standards - tailored
Detailed T&E planning, SEP, LCMP updates
CARD update

The T&E Engineer identifies other contract requirements: incentives programs; production and operational test & demo requirements; and field performance and sustainment analyses to meet T&E objectives. The T&E Engineer ensures successful validation of the intended operational capabilities through operational test and evaluation. The T&E Engineer supports Developmental Test and Evaluation (DT&E), Initial Operational Test and Evaluation (IOT&E), Operational Test and Evaluation (OT&E), Initial Operational Capability (IOC) and Full Operational Capability (FOC) to meet community T&E objectives.

T&E Engineers' Contributions to the Engineering Life Cycle Framework

Relationship to the SE Organization

The T&E Engineer plans and executes essential T&E engineering and management efforts within the context and full support to the overarching Systems Engineering function. The T&E Engineer ensures that each T&E contribution is timely, adequate, consistent, and compliant. The T&E Engineer ensures that their contributions are channeled through the Systems Engineering *Analyses and Control* and *V&V* activities. Systems Engineers manage the engineering process and activities depicted in Figure 3 while the T&E Engineer contributes to this process by supporting concept and architecture development and analyses; modeling and simulation efforts; and technology development; design trades, V&V, and sustainability analyses. The T&E Engineer supports the requirements analyses and allocation process, to assure that the specifications are well stated, are testable, and that associated test scenarios are unambiguous. Further, the T&E Engineer develops/derives verification and test requirements. The scope of the T&E Engineers activities with system engineering includes evaluation of verification and validation of interfaces, functions, and integration and test at the component, segment and system levels. The T&E Engineer ensures specification test strategies, plans, and methodologies developed by System Engineering are adequate. The T&E Engineer evaluates integrated test plans and procedures for space system hardware, software, and information exchanges to verify/validate developmental, qualification, acceptance, and operational testing requirements. The T&E Engineer ensures results of testing are applied to the overall engineering effort through systematic control, collaboration and sharing across the organization to facilitate system development and implementation.

Relationship to other SEDs

T&E, by the nature of their function, must interface with every specialty discipline involved with the design, development, manufacturing, deployment and operation of a system to ensure that their requirements and test needs are addressed as part of the T&E program. For example, the T&E Engineer works with:

- System Safety to plan and conduct tests of safety devices, perform demonstrations for manufacturing and production, and operations and maintenance safety procedures
- Reliability Engineers to establish and conduct reliability testing and implement the reliability growth program.
- Information Assurance Engineer to demonstrate integrity of system information is safeguarded; anti-spoofing measures are effective.
- Manufacturing & Producibility Engineer to develop and implement production tests, e.g., 1st article, acceptance tests.
- Design Engineering in a multi-disciplinary process during all program phases to evaluate requirements and validate the flow-down of verification methods for credible test and evaluation solutions for spacecraft, payload, C3 data processing, and mission operations.
- Integrated Logistic Support to plan, prepare for and conduct maintenance test demonstrations, Built-in-Test (BIT), diagnostics development and verification.
- Quality Assurance to assist to define and validate process controls and quality conformance verification.
- Prognostics Health Management to assist in architecting and validating diagnostics capabilities.
- Software Engineer to develop prototyping approaches, plan and conduct software testing.

Tools Selection and Use

The T&E Engineer considers effectiveness and efficiencies gained by selecting and using the best choice of T&E tools needed to support requirements for test, modeling, simulation, prototyping, test data evaluation, information sharing, automated data exchanges with other tools, and other considerations.

Typical T&E Functions Requiring Tools
Modeling & Simulations
Test Requirements Development
Test Automation
Test assets tracking, scheduling, assessments
Anomaly / deficiency status tracking and resolution

Engineering Activities and Products over the Life Cycle

The Program Office and the operational test organization determine the full scope of T&E activities, events, and products. There are many aspects of the T&E program that are required to ensure successful developmental and operational V&V of a system. The following subsections delineate T&E contributions to engineering activities and technical products by DoD acquisition phase.

1. **Materiel Solution Analysis.** During this phase the T&E Engineer prepares the ITT Charter and conducts the ITT. The T&E Engineer develops the TES and provides inputs to the ASP, TDS, and DMS. The T&E Engineer supports the concept development activities providing inputs and factors for concept, architecture, technology studies and demonstrations, and trades. The T&E Engineer supports the development of technology roadmaps and assists to identify and mitigate technical and program risks. The T&E Engineer assists the operating command to develop the operational concept(s), prepare the ICD, STAR, operational

MSA Phase – Technical Products Required	
SMC T&E Technical Products	**T&E Contributions to Other Organizations' Products**
ITT Charter	Inputs to Operational Concepts
TES; Inputs ASP, TDS, DMS	Inputs to ICD, STAR
T&E inputs and factors for concept, architecture, technology studies, and trades	Inputs to AoA Studies
Roadmap inputs – mitigations of T&E risks	DoDAF CVs, OVs
Inputs to SEP, LCMP, CARD	

architectural products (OVs, CVs), support AoA studies, and threat assessments. The T&E Engineer contributes to development of the MSA Phase technical products.

2. **Technology Development.** During this phase the T&E Engineer continues to provide inputs to and supports the JCIDS process. The T&E Engineer also supports all the engineering activities highlighted within the box titled *Engineering Activities for Development & Design* Figure 4 to commence system definition and development. The T&E Engineer develops and contributes to development of the TD Phase technical products.

TD Phase – Technical Products Required	
SMC T&E Technical Products	T&E Contributions to Other Organizations' Products
ITT charter update	Inputs to Operational Concepts
TEMP	Inputs to CDD, STAR
Inputs ASP, TDS, DMS	
T&E inputs and factors for concept, architecture, technology studies, and trades	Inputs to AoA Studies
Roadmap inputs	DoDAF CVs, OVs
Architectural inputs: System & Service DODAF Views; ISP	
T&E verification requirements inputs & evals: TRD, SRD, Specs	
RFP inputs: SOO, PWS Tasks, CDRLs, DIDs; T&E standards	
Inputs to detailed eng planning, M&S Support Plan, SEP, LCMP	

The T&E Engineer supports the concept, architectural, technology development, and engineering trades and analyses to ensure the concept, architectural, technology and design solutions are determined:

- Through the appropriate evaluations, analyses and trades, modeling and simulation (M&S) efforts, tests, demonstrations.
- With consideration of the required test, M&S, and other resources
- With the complement of approaches, including test, M&S, demonstration, to achieve technical maturity
- In conjunction with the complementary verification and validation (V&V) requirements

The T&E Engineer participates in technology maturation activities throughout this phase. The responsibility includes assessing the risk mitigation "burn-down" approach, establishing the adequacy of hardware and software prototyping, M&S and resources. The T&E Engineer assesses the results and provides recommendations for transition to higher maturity levels.

Using the TES as a baseline, the T&E Engineer prepares and coordinates the TEMP with all stakeholders to provide the roadmap for DT&E and OT&E. The TEMP addresses the use of resources, measures of effectives and suitability, defines the critical operational issues and provides program compliance direction for T&E to assure the system is capable of meeting its requirements and implementing the concept of operations. The T&E Engineer plans and documents the M&S approach, and prepares the M&S Support Plan in conjunction with System Engineering. M&S will be used to verify and validate system capabilities throughout DT&E and OT&E.

3. **Engineering & Manufacturing Development.** During this phase the T&E Engineer continues to provide inputs to and supports the JCIDS process. The T&E Engineer also supports all the engineering activities highlighted within the box titled *Engineering Activities for Development & Design* Figure 4 to commence detailed system design and development. The T&E Engineer develops and contributes to development of the EMD Phase technical products.

EMD Phase – Technical Products Required	
SMC T&E Technical Products	**T&E Contributions to Other Organizations' Products**
ITT charter update	Inputs to Operational Concepts
Updates to TEMP, ASP, TDS	Inputs to CPD, STAR
Architectural inputs: System & Service DODAF Views; ISP	
T&E inputs and factors for design analyses and trades	Inputs to AoA Studies
T&E verification requirements inputs & evals: TRD, SRD, Specs	
Inputs to detailed eng planning, SEP, LCMP, CARD	Input to DoDAF AVs, CVs, DIVs, OVs
RFP inputs: SOO, PWS Tasks, CDRLs, DIDs; T&E standards	
Evals of test plans, procedures; & results; Assessments of integration, fielding, sustain docs	
System and Service DODAF Views; TVs, ISP inputs	

The T&E Engineer updates and coordinates the TEMP and M&S Support Plan. The T&E Engineer assists to determine test requirements for long lead procurements and GFE. The T&E Engineer supports the engineering requirements development and design efforts to ensure the design solutions are determined:

- Through the appropriate evaluations, analyses and trades, modeling and simulation efforts, tests, demonstrations.
- With consideration of the required test and M&S equipment, test software, test sites and facilities, personnel resources
- To attain commitments and schedule resources
- In conjunction with the complementary verification and validation requirements
- With consideration of test requirements for integration, fielding, and sustainment test assets

The T&E Engineer ensures the adequacy of the entire verification program to include contractual establishment and adherence to qualification and acceptance testing to include bottoms-up developmental qualification testing of materials, piece parts, components, assemblages and integration of assemblages; reliability growth testing, safety demonstrations, maintainability demonstrations, and aging and surveillance testing of limited life materials and parts. The T&E Engineer ensures adequate qualification of critical manufacturing processes.

The T&E facilitates or supports an effective failure reporting and corrective action system (FRACAS), problem identification and resolution process, and risk management program. The T&E Engineer reports, validates, tracks, evaluates and responds to deficiency reports in accordance with TO 00-35D-54, USAF Deficiency Reporting and Investigating System. The T&E Engineer compiles and scores test data and implements and conducts the Test Data Scoring Board (TDSB).

The T&E Engineer assists the PM to prepare the certification for Operational Test & Evaluation (OT&E), and conduct the OT&E program. T&E efforts also concentrate on refining and finalizing the Integrated

Test Plans to perform qualification and acceptance testing required during Production Deployment and Operations Support Phase.

4. **Production & Deployment, Operations & Support.** The T&E Engineer continues to provide inputs to and supports the JCIDS process. The T&E Engineer continues to oversee the DT&E program through the systems engineering process to perform V&V and support development and performance of the IOT&E and OT&E program. The T&E Engineer develops and contributes to the development of the Production and Deployment / Operations and Support Phase technical products. The T&E Engineer assists the PM in the preparation, coordination and issuance of the *Certificate of System Readiness* to enter OT&E.

P&D / O&S Phase – Technical Products Required	
SMC T&E Technical Products	**T&E Contributions to Other Organizations' Products**
Inputs to tech baseline engineering changes	Supportability Analyses Rpt
Analyses of production quality reports and test reports	Operational Assessments
Analyses of OT&E results; performance reports; field test reports	Survivability Assessments
Inputs to FRACAS	
Transition & Fielding Docs	

The T&E Engineer continues to ensure the adequacy of the entire verification program to include contractual establishment and adherence to qualification and acceptance testing to include bottoms-up quality conformance and acceptance testing of materials, piece parts, components, assemblages; production acceptance and first article testing; reliability growth testing, integration testing, and aging and surveillance testing.

The T&E Engineer continues to support the engineering requirements development and design efforts to ensure the design solutions are determined:

- Through the appropriate evaluations, analyses and trades, modeling and simulation efforts, tests, demonstrations.
- With consideration of the required production test equipment, test software, test sites and facilities, personnel resources
- To attain commitments and schedule resources
- In conjunction with the complementary verification and validation requirements
- With consideration of test requirements for integration, fielding, and sustainment test assets

The T&E facilitates or supports an effective FRACAS, problem identification and resolution process, and risk management program. The T&E Engineer reports, validates, tracks, evaluates and responds to deficiency reports IAW TO 00-35D-54, USAF Deficiency Reporting and Investigating System. The T&E Engineer continues to compile and score test data and conduct the TDSB.

After system deployment, T&E provides technical support, documentation, and test planning and evaluation support to supportability assessments, system modifications, sparing procurements; and certifications.

T&E Engineers' Contributions to Program and Project Management

Each SMC program defines their business model and approach based primarily on program objectives, technical challenges, organizational structure, and required engineering planning including test and evaluation for cost-effective execution.

T&E Engineer supports Program Management by initially developing an integrated test strategy for the program, scoping the T&E efforts over the acquisition life-cycle phases, then developing and implementing the T&E program planning to implement the required statutes and regulations and to achieve Program Office objectives and requirements. The planning defines the T&E tasks and functions to be performed and products to be developed; timing of tasks, task outputs, resources (skills, tools, test equipment and facilities). The T&E Engineer plans tasks to integrate T&E activities within the Program Office, test organizations, operational community, and between Contractors and stakeholders. The T&E Engineer coordinates the T&E planning with the Program Office, ITT, stakeholders, test community as appropriate and ensures planning consistency with the other functional and acquisition plans (i.e. SEP, IMP, LCMP, LCSP).

The T&E Engineer provides full support to define the program and technical objectives where T&E related challenges and risks are known or anticipated. The T&E Engineer assists to establish the business model, develop program planning and schedules, and define and implement program processes. Execution of the T&E planning is typically defined through an Operating Instruction which implements SMC and higher level instructions, policies, and directives. The PMP Engineer ensures the T&E components of the program are appropriately represented in the program plans, program schedules, work breakdown schedules, cost estimates. The T&E Engineer also reports their technical performance and progress. The T&E Engineer shares in the risk management responsibilities to identify, assess, and propose mitigating actions of T&E related risks. They also support the Program Manager's problem identification, resolution, and decision-making processes. The T&E Engineer assists the PM and the operational test organization to prepare, coordinates, and implements the ITT charter.

The T&E Engineer contributes to the development of the program management products identified in the Table.

SMC Program Management Products
PMD
SEP, IMP, IMS, WBS
Decision-making & problem solving inputs
Technical progression and issues reporting
LC Cost Estimate (CARDs)
Processes (OIs)
Risk Management Inputs

Appendix B – Software Engineering

Software engineering is an engineering discipline with a focus on all aspects of software, which includes software development, design, production, verification, operation and maintenance. It is the application of a systemic, quantifiable and disciplined approach to analyzing, designing, assessing, implementing, testing, maintaining and developing software. Software is a well-defined and established SMC Specialty Engineering Discipline (SED), and is an integral element of all space and missile systems today. At SMC, there are instructions, guidance, and SMC Staff resources available to assist the Program Office Software Engineer to stand-up and execute essential software acquisition engineering activities and to implement Software Engineering mandates and best practices.

The Software Engineer plans and executes the essential software engineering and management efforts in an integrated and effective manner to ensure that each Software SED contribution is timely, adequate, consistent, and compliant. Software is an integral part of the overall systems planning and design. The Software Engineer POC ensures that the software engineering contributions are channeled through the Systems *Engineering Analyses and Control* activity.

Applicable governance, standards, and guidance

Policy, directives, and instructions that mandate SMC software engineering related program requirements are included in a wide range of mandates including those providing requirements for acquisition, Systems Engineering, Test and Evaluation (T&E), Human Systems Integration (HSI), Systems Safety, and others. Table 4 below identifies the significant governance, standards, and guidance that require SMC compliance for Software Engineering.

Table 4 Governance, standards, and guidance that shape the Software Engineering discipline

Document No	Governance Title	Issue
DoDI 5000.02	Operation of the Defense Acquisition System	08 Dec 008
DoDD 8500.01E	Information Assurance (IA)	
AFI63-101	Acquisition and Sustainment Life Cycle Management	27 Apr 11
AFI63-1201	Life Cycle Systems Engineering	15 Feb 11
SMCI 63-103	Software Acquisition Process Improvement Instruction	24 Oct 02
SMCI 63-104	Software Acquisition Instruction	21 Nov 05
SMCI 63-105	AFSPC Section 508 Implementation Policy	26 Jan 07
SMCI 63-108	Software Acquisition Management Plan (SWAMP)	9 Feb 11
SMCI 63-1205	Space System Safety Policy, Process and Techniques	20 Aug 07
Document No	**Standards Title**	**Issue**
SMC-S-001	Systems Engineering Requirements And Products	12 July 10
SMC-S-002	Configuration Management	13 Jun 08
SMC-S-003	Quality Assurance Space Vehicles and Launch Vehicles	13 Jun 08
SMC-S-012	Software Development for Space Systems	13 Jun 08
SMC-S-021	Technical Reviews & Audits for Systems, Equip & Computer Software	15 Sep 09
SMC-S-023	Human Computer Interface Design Criteria Volumes 1 & 2	19 Mar 10
MIL-STD-1472F	DoD Design Criteria Standard for Human Engineering	23 Aug 99
MIL-STD-1833	Test Requirements For Ground Equipment And Associated Computer Software Supporting Space Vehicles	13 NOV 89
MIL-STD-882C	System Safety Program Requirements	19 Jan 93

ISO/IEC 15939	Systems and software engineering – Measurement process	23 Jul 07
Document No	**Guidance Title**	**Issue**
AF T.O. 00-5-16	Technical Manual Software Manager's Manual	15 Oct 03
TOR-2004(3909)3405	Metrics-based Software Acquisition Management.	May 04
TOR-2006(8506)-5749	Mission Assurance Tasks for Software	30 Apr 07
TOR-2007(8546)-6018 Rev A	Mission Assurance Guide	
TOR-2011(8591)-10517e	Software Review Assessment Primer	
EIA/IEEE Interim Standard J-STD-016-1995	Standard for Information Technology, Software Life Cycle Processes Software Development Acquirer-Supplier Agreement	Sep 95
IEEE 1044-1993	Standard Classification for Software Anomalies	Jan 95
IEEE Std 610.12-1990	Glossary of Software Engineering Terminology	Sep 90
CMMI-DEV, V1.3	CMMI® for Development, Improving Processes for Developing Better Products and Services	Nov 10
SMC-G-003	SMC CMMI-A Process Appraisal Method (2009)	
DAG, Chapter 4.4.16	Software	14 Oct 04
SAG	Software Acquisition Guidebook (interim) http://www.projectofficer.org/SAG/swindex.htm	
	SMC Clinger-Cohen Act (CCA) Compliance Guidebook	

DoDI 5000.02 establishes requirements for software design progression as an element of Integrated System Design to include technical design reviews and post-design review assessments. This Instruction also requires a Software Resources Data Report (SRDR) for all major contracts and subcontracts for contractors developing/producing software elements within acquisition category (ACAT) I and IA programs and pre-Major Defense Acquisition Program (MDAP) and pre-Major Automated Information System (MAIS) programs subsequent to Milestone A approval for any software development element with a projected software effort greater than $20M.

DoDD 8500.01E applies to weapons systems software, that is physically part of, dedicated to, or essential to a platform's mission performance where there is a platform Information Technology (IT) interconnection.

Date Item Title	Date Item Description
Software Development Plan (SDP)	SMC-S-012 Appendix H
Software Test Plan (STP)	DI-IPSC-81438A
Software Installation Plan (SIP)	DI-IPSC-81428A
Software Transition Plan (STrP)	DI-IPSC-81429A
Interface Requirements Specification (IRS)	DI-IPSC-81434A
System/Segment Design Description (SSDD)	DI-IPSC-81432A
Interface Design Description (IDD)	DI-IPSC-81436A
Software Requirements Specification (SRS)	DI-IPSC-81433A
Software Design Description (SDD)	DI-IPSC-81435A
Database Design Description (DBDD)	DI-IPSC-81437A
Software Test Description (STD)	DI-IPSC-81439A
Software Test Report (STR)	DI-IPSC-81440A
Software Product Specification (SPS)	DI-IPSC-81441A
Software Version Description (SVD)	DI-IPSC-81442A
Software User Manual (SUM)	DI-IPSC-81443A
Computer Operation Manual (COM)	DI-IPSC-81446A
Computer Programming Manual (CPM)	DI-IPSC-81447A
Firmware Support Manual (FSM)	DI-IPSC-81448A

At SMC, the Software Engineering discipline conforms to SMC's Software Development for Space System, SMC-S-012. This standard provides requirements and expectations for contractor software development activities. It applies to the development of systems that contain software (e.g., hardware-software systems, software-only systems, and stand-alone software products). It is also relevant to government in-house agencies, contractors, or subcontractors performing software development. The SMC Software Acquisition Instruction SMCI 63-104 provides requirements for software-intensive program acquisitions to ensure successful acquisition of software-intensive systems. This instruction identifies activities and processes that must be followed. From a safety aspect, the Software

Engineering discipline is also subject to the Space System Safety Policy Process and Techniques, SMCI 63-1205 and the MIL-STD-882C System Safety Program Requirements standard at SMC. This standard specifies a list of DIDs that are required as contract deliverables which are exhibited in the table below. SMCI 63-104 also provides a list of life cycle milestone reviews for the DID's and their software development products for which CDRLs should be considered.

Software Engineers' Contributions to Acquisition Life Cycle Framework

The DoD acquisition life cycle is defined by DoDI 5000.02. The Software Engineers' contributions over this life cycle are best represented within the phase of acquisition. Figure 5 below provides the acquisition life cycle framework within which Software Engineers perform as well as the products that the Software Engineers develop or contribute to their development. This figure along with SMCI 63-104, Software Acquisition Instruction, summarizes the requirements to perform software engineering planning, supports pre- and post-contract award acquisition activities, and performs software engineering and management across the system lifecycle. SMC Program Offices establish and implement software engineering program strategies and objectives consistent with the tenets of appropriate policies, SMC acquisition objectives, and program objectives. The directorate or the Program Office prepares an initial Software Acquisition Management Plan (SWAMP) at the MDD activity for MDA approval. The final SWAMP is then updated prior to the performance of the System Functional Review (SFR). The Program Office develops, attains approval for, and incorporates software engineering planning into the Systems Engineering Plan (SEP) and higher level integrated planning (e.g., IMP) in accordance with current DoD policy. This planning is firmly based on program and technical objectives, strategies, DoD mandates, and instructions.

An effective software engineering program supports all of the major acquisition activities throughout the full system life cycle. The Software Engineer sufficiently defines the software engineering program planning to achieve the software engineering and overall program objectives and requirements. The planning specifies tasks and functions to be performed, timing of tasks, resources required, and products to be developed. The software engineering planning are then reflected appropriately in the WBS, IMP, IMS, and other program documents that address software engineering related elements. The Software Engineer delineates the program office strategy for integrating software into the systems engineering process and describes the software management approach in the SWAMP. The software engineering planning is executed concurrently with the Program Office Operating Instruction that documents the process to perform, control, and integrate all software engineering and management activities for each phase of acquisition.

The SMC Program Office software engineering planning (usually contained in the SWAMP, SEP, IMP) and the processes delineated in the OI are also based upon the appropriate program-approved life cycle. The following subsections delineate software engineering contributions to acquisition activities and products by DOD acquisition Phase. Refer to SMCI 63-104 for a more complete list of software engineering activities and products that are prepared by the Program office and their Contractors.

MSA Phase – SMC Acquisition Products
PMD, ASP, TDS, DMS, TES
Software Cost Estimate
RFP inputs (software requirements; assessment requirements; High level software concepts
APB, CCA, SEP, LCMP, draft SWAMP

1. **Materiel Solution Analysis.** During this phase the Software Engineer provides inputs to and supports most program acquisition activities to include the development of the acquisition strategy, inputs to the cost estimates, solicitation/Request for Proposal (RFP) development for Contractor studies, and proposal evaluation activities.

The Software Engineer also contributes to the development of the MSA Phase acquisition products.

2. **Technology Development.** The Software Engineer provides inputs to and supports all program acquisition activities to include the development of the acquisition strategy, updates to the software cost estimate and development of the Cost Analysis Requirements Description (CARD), solicitation/RFP development and proposal evaluation activities. The Software Engineer is key to the solicitation/RFP development and proposal evaluation in addition to identifying the software related contract requirements, software tasks, test and demonstration requirements to meet software engineering objectives. The Software Engineer also contributes to the development and updates to the TD Phase acquisition products. At TD Phase, software design evolves and is established at the allocated baseline level and architecturally documented to reflect a system level maturity commensurate for a successful PDR.

TD Phase – SMC Acquisition Products
Updates to ASP, TDS, DMS
Software Cost Estimate Update / CARD Development
RFP: SDP objectives in the SOO; software related tasks in SOW, Software data products in CDRLs; SMC-Software standards - tailored
APB: baseline software cost, risks, and performance
Software planning e.g., (SWAMP), SEP, LCMP
Software verification /TEMP updates

3. **Engineering & Manufacturing Development.** The Software Engineer provides inputs to and supports all program acquisition activities to include updates to the acquisition strategy and updates to the software cost estimate to reflect the actual technical solutions determined and updates to the CARD. The Software Engineer supports the solicitation/RFP development and proposal evaluation activities which include providing the technical inputs including technical requirements, compliance standards, engineering approaches, incentives, and warranty programs to meet program objectives. The Software Engineer identifies other contract requirements as necessary to meet software engineering objectives and also contributes to the development and updates to the EMD Phase acquisition products.

EMD Phase – SMC Acquisition Products
Updates to ASP, TDS, DMS
Software Cost Estimate; CARD update
RFP: Software objectives in the SOO; Software related tasks in SOW, Software data products in CDRLs; SMC- Software Engineering standards - tailored
APB: baseline software cost, risks, and performance
Software planning (SWAMP, SDP), SEP, LCMP
Software verification /TEMP updates

During this phase, Software Engineering efforts are concentrated on evolving and assessing the software design to assure that 1) the software design, including logic, algorithm, architectural artifacts, etc, is evolving consistent with the baselined requirements and trade decisions, 2) software design qualification is progressing consistent with the contract requirements, and 3) the software will conform to regulatory requirements.

The Software Engineer supports the development of the acquisition, technology demonstration, and test strategies to ensure successful implementation of software capabilities. The Software Engineer supports the definition of contract requirements such as Software performance work statements and specification requirements, and detailed design specification requirements associated with software performance, development, and qualification to meet the system or enterprise level requirements and capabilities. The Software Engineer also supports the definition of incentives programs, T&E, RAM requirements.

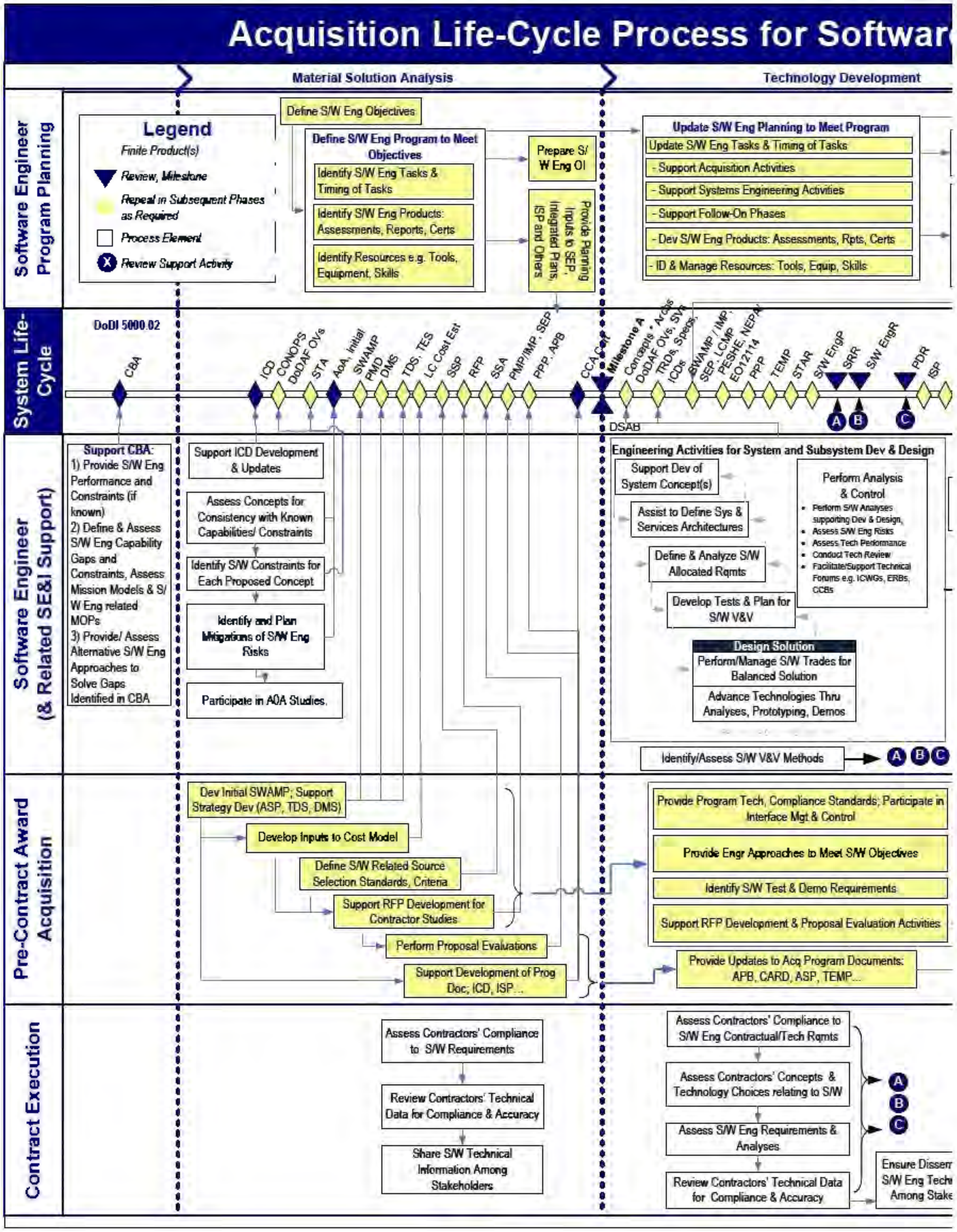
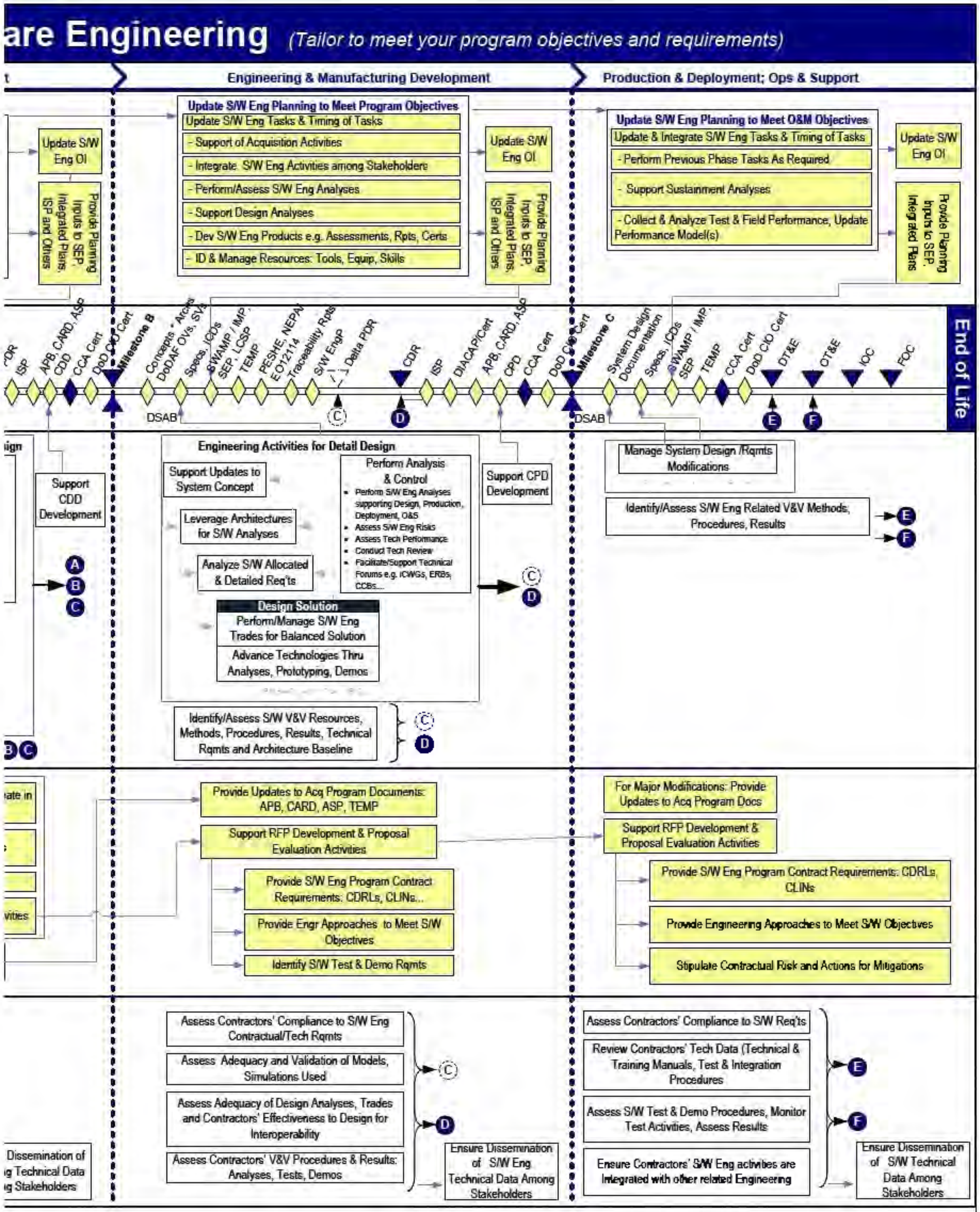


Figure 5 Acquisition life cycle process for SMC Software Development


are Engineering (Tailor to meet your program objectives and requirements)
Engineering & Manufacturing Development
Production & Deployment; Ops & Support
Update S/W Eng Planning to Meet Program Objectives
Update S/W Eng Tasks & Timing of Tasks
- Support of Acquisition Activities
- Integrate S/W Eng Activities among Stakeholders
- Perform/Assess S/W Eng Analyses
- Support Design Analyses
- Dev S/W Eng Products e.g. Assessments, Rpts, Certs
- ID & Manage Resources: Tools, Equip, Skills
Update S/W Eng OI
Provide Planning Inputs to SEP, Integrated Plans, ISP and Others
Update S/W Eng Planning to Meet O&M Objectives
Update & Integrate S/W Eng Tasks & Timing of Tasks
- Perform Previous Phase Tasks As Required
- Support Sustainment Analyses
- Collect & Analyze Test & Field Performance, Update Performance Model(s)
Provide Planning Inputs to SEP, Integrated Plans
End of Life
Milestone B
Milestone C
DSAB
CDR
DT&E
OT&E
IOC
FOC
Engineering Activities for Detail Design
Support Updates to System Concept
Leverage Architectures for S/W Analyses
Analyze S/W Allocated & Detailed Req'ts
Perform Analysis & Control
Perform S/W Eng Analyses supporting Design, Production, Deployment, O&S
Assess S/W Eng Risks
Assess Tech Performance
Conduct Tech Review
Facilitate/Support Technical Forums e.g. ICWGs, ERBs, CCBs...
Design Solution
Perform/Manage S/W Eng Trades for Balanced Solution
Advance Technologies Thru Analyses, Prototyping, Demos
Support CDD Development
Support CPD Development
Identify/Assess S/W V&V Resources, Methods, Procedures, Results, Technical Rqmts and Architecture Baseline
Manage System Design /Rqmts Modifications
Identify/Assess S/W Eng Related V&V Methods, Procedures, Results
Provide Updates to Acq Program Documents: APB, CARD, ASP, TEMP
Support RFP Development & Proposal Evaluation Activities
Provide S/W Eng Program Contract Requirements: CDRLs, CLINs...
Provide Engr Approaches to Meet S/W Objectives
Identify S/W Test & Demo Rqmts
For Major Modifications: Provide Updates to Acq Program Docs
Support RFP Development & Proposal Evaluation Activities
Provide S/W Eng Program Contract Requirements: CDRLs, CLINs
Provide Engineering Approaches to Meet S/W Objectives
Stipulate Contractual Risk and Actions for Mitigations
Assess Contractors' Compliance to S/W Eng Contractual/Tech Rqmts
Assess Adequacy and Validation of Models, Simulations Used
Assess Adequacy of Design Analyses, Trades and Contractors' Effectiveness to Design for Interoperability
Assess Contractors' V&V Procedures & Results: Analyses, Tests, Demos
Ensure Dissemination of S/W Eng Technical Data Among Stakeholders
Assess Contractors' Compliance to S/W Req'ts
Review Contractors' Tech Data (Technical & Training Manuals, Test & Integration Procedures
Assess S/W Test & Demo Procedures, Monitor Test Activities, Assess Results
Ensure Contractors' S/W Eng activities are integrated with other related Engineering
Ensure Dissemination of S/W Technical Data Among Stakeholders

4. **Production & Deployment, Operations & Support.** The Software Engineer provides inputs to and supports all program acquisition activities to include updates to the acquisition strategy and updates to the software cost estimate to reflect the actual technical solutions determined and updates to the CARD. The Software Engineer supports the solicitation/RFP development and proposal evaluation activities. The Software Engineer identifies other contract requirements: production and field test & demo requirements: field performance and sustainment analyses to meet Software Engineering objectives.

P&D /O&S Phase – SMC Acquisition Products
Updates to ASP, DMS, Software Cost Estimate, CARD
RFP: Software objectives in the SOO; Software related tasks in SOW, Software data products in CDRLs; SMC- Safety standards - tailored
SWAMP
Detailed Software planning, SEP, LCMP, updates

Software Engineers' Contributions to Engineering Life Cycle Framework

Relationship to the SE Organization

The Software Engineer plans and executes the essential software engineering and engineering management efforts in an integrated and effective manner within the context and full support of the overarching Systems Engineering function and current software related governance. The Software Engineer ensures that their SED contributions are timely, adequate, consistent, and compliant. The Software Engineer ensures that their contributions are channeled through the Systems Engineering Analyses and Control activity.

Systems Engineers manage the engineering process and activities depicted in Figure 3 while the Software Engineer contributes to this process. Software Engineers support concept & architecture development and analyses; Modeling and Simulation (M&S) efforts; technology studies with potentially impacted software challenges. They also participate in technical studies and technical solutions trades when software engineering is either a factor or a component of the proposed technical solution. They provide design analyses contributions to mitigate potential causes to system level hazards. They assess and propose alternative mitigating actions or solutions. The Software Engineer also works closely with the System Engineers performing interface analyses and functional analyses to leverage the required software related analyses. The Software Engineer also supports the integration and verification & validation planning and execution.

In performing the management and control function, the Systems Engineer effectively integrates all engineering functions through the full system life cycle. The Software Engineer ensures their technical contribution to the overall engineering advances and is appropriately applied through systematic control, collaboration and sharing across the organization. In addition the Software Engineering products are used by the other Specialty Engineers to perform their unique contributions, and are provided to technical and program management for decision making.

Relationship to other SEDs

The Software Engineer SED relationship to other SEDs is summarized in Figure 1. Software Engineer interactions with the other SEDs are critical to perform and integrate their engineering contributions to the system development efforts.

The Software Engineer collaborates with the Systems Engineer, Architecture Engineer, T&E Engineer, and Design Engineer to ensure the system architecture includes software related technology, physical and functional solutions that implement the software performance requirements as well as for built-in diagnostics, test and fault management requirements for real-time or periodic system integrity prognostics, health and/or fault reporting and fault corrections.

The Software Engineer collaborates with the T&E Engineer to strategize, plan, and execute the software DT&E and OT&E. The Software Engineer collaborates with the Systems Engineer and the T&E Engineer to strategize, plan, and execute software prototyping or rapid software development to validate requirements, explore software design alternatives, and confirm performance.

The Software Engineer supports the Reliability Engineer in the performance of the failure analyses to identify software failure modes and determine reliability solutions that may be partially achieved through application of software techniques and reliability measurement technologies.

Software Engineers team with the System Safety Engineers to perform software contribution to system risk analyses and to determine items or functions when performed or whose failure could lead to a hazardous system state -- one that could result in unintended death, injury, loss of property, or environmental harm. They also work with Reliability Engineers to improve the dependability, reliability, maintainability, and availability of the software products that are designed and developed.

Software Engineers work closely with Human Systems Integration to ensure systems are design that can be operated and maintained by users; and are habitable and safe with minimal software and occupational health hazards. The Software Engineer works closely with the Logistics Engineers to determine software maintenance and maintainability requirements and technical solutions. Implementation of the software related requirements are initially conveyed in the maintenance concept and system architecture. Software Engineers play an intricate role with respect to Information Assurance and, in particular, to software items or portions thereof whose failure could lead to a breach of system security or system privacy protection.

Interactions among the Software Engineer and the other disciplines are extensive. Refer to the SMC Software instructions and guidance Table 4 for more detailed discussion of these interactions.

Tools Selection and Use

The Software Engineer considers effectiveness and efficiencies gained by selecting and using the best choice of Software Engineering tools.

Typical Software Engineering Functions Requiring Tools
Software Development Planning
Software Development Implementation
Software Development
Software Configuration Management
Software Modeling and Architecture Development
Software Testing
Software Improvements/Enhancements (e.g. CMMI, ISO 9000, ISO 15504)
Software Cost Estimating

Engineering Activities and Products over the Life Cycle

Engineering activities that are prevalent in software engineering include:
Note: this is not intended to be an all-inclusive list of activities. Each Software Engineer must scope their programs to determine their required software engineering activities.

- Early in the life cycle, identify software technology challenges.
- Support concept and architectural development; provide software related factors into concept and architectural trades.
- Contribute to identify all software components of each proposed concept, architecture, and design solution to include operational/mission software; engineering software to perform modeling and simulations, test, and analyses; training software; production, integration; deployment, and sustainment software.
- Assist in the conceptualization and realization of net-centric migration when SMC Program undergoes major modifications.
- Assist in the conceptualization and realization of information assurance and system security as they relate to software solutions.
- Determine all applicable software related governance that applies to the Program Office.
- Identify, and extract requirements via requirements analysis. Assess Contractors' requirements analysis performance.
- Ensure the software design solution practices lead to well documented rationale and are balanced with all pertinent factors, e.g., reliability, growth potential, reusability, security, and other factors.
- Assist to define and implement an effective measurement analysis and continuous improvement program to include collection and analysis of software related metrics as well as technical performance measures.
- Ensure Contractor performance of software quality engineering / quality assurance.
- Ensure Program Office and Contractors retain adequate configuration control of the evolving software design.
- Assist to plan, monitor, and assess software test / V&V results to ensure the system meets its software Technical Performance Measures as an integral and critical part of the software development process that ensures software deficiencies are revealed and resolved as early as possible.

Software Analysis and Impact Assessment: A software analysis is performed to determine the impact on and by each system product and process alternative. Proposed software-related tradeoffs and analyses are presented by the Software Engineer through the System Software Engineering process to determine balanced technical solutions. The following subsections delineate Software Engineer contributions to engineering activities and technical products by DOD acquisition phase. Refer to SMCI 63-108 for a more complete list of Software Engineering activities and products prepared by the Program Office and their Contractors.

MSA Phase – Technical Products Required	
SMC Software Technical Products	**S/W Contributions to Other Organizations' Products**
High level assessment proposed concepts & architectures	Operational Concepts
Software engineering inputs and factors for concept, architecture, technology studies, and trades	AoA Studies
Software Req'ts (draft)	Initial Capabilities Doc (ICD) Dev
Roadmap and architectural inputs – Identification & mitigations of potential hazards	DoDAF CVs, OVs

1. **Materiel Solution Analysis.** During this phase the Software Engineer may provide inputs to and support the Capabilities Based Assessment process and the JCIDS process. The Software Engineer evaluates proposed concepts and architectures to identify and assess implications of software design and development, and to provide recommendations for each alternative. The Software Engineer assists to define, refine,

and validate feasibility of software related requirements to support Initial Capabilities Document (ICD) development and possibly Systems Requirements Document (SRD) development. Legacy program may employed TRD. The Software Engineer also contributes to the development of the MSA Phase technical products.

2. **Technology Development.** During this phase the Software Engineer continues to provide inputs to and supports the JCIDS process. The Software Engineer identifies and assesses software related technology challenges including algorithm development, software, computing techniques, security assurance, and other software design challenges. The Software Engineer also supports all the engineering activities highlighted within the box titled *Engineering Activities for System & Segment Development & Design* Figure 5 to commence system definition and development. Software Engineer develops and contributes to development of the TD Phase technical products.

TD Phase – Technical Products Required	
SMC Software Technical Products	**S/W Contributions to Other Organizations' Products**
Inputs to System Concepts	Operational Concepts
Factors for Studies/ Trades	Operational Assessments
Software Tech Req'ts, TRD, SRD, Specifications, ICDs, Standards Selection/ Tailor	Capabilities Development Doc (CDD)
Software inputs to ISP	DoDAF CVs, OVs, AVs, SVs,

3. **Engineering & Manufacturing Development.** Software Engineer continues to provide inputs to and supports the JCIDS process. The Software Engineer supports all the engineering activities highlighted within the box titled *Engineering Activities for Detailed Design* Figure 5 to commence detailed systems definition and development. The Software Engineer ensures a process is in place to report, analyze, and mitigate software development issues during DT&E. The Software Engineer provides inputs to and supports the JCIDS process.

EMD Phase – Technical Products Required	
SMC Software Technical Products	**S/W Contributions to Other Organizations' Products**
Update System Concept	Operational Concepts
Technical Studies/ Trades	Operational Assessments
System Tech Req'ts, TRD, SRD, Spec, ICDs; Software req'ts flow-down / allocations	Capabilities Production Doc (CPD)
Inputs to system design, production, fielding, sustain docs	DoDAF Data and Products
Software Eng inputs to ISP	
Software evaluations of Tech Orders, operations manuals	
Test, Demo reports	

Refer to SMCI 63-104, *Software Acquisition Process for* Software Engineer activities and products typically required during each phase. The Software Engineer develops and contributes to the development of the EMD Phase technical products.

4. **Production & Deployment, Operations & Support.** The Software Engineer continues to ensure software meets the contractual software development requirements, and integration activities, and is under configuration control. The Software Engineer continues to identify, assess, and resolve software related risks and issues as they arise. The Software Engineer develops and contributes to the development of the Production & O&S Phase technical products.

P&D / O&S Phase – Technical Products Required	
SMC Software Technical Products	**S/W Contributions to Other Organizations' Products**
Inputs tech baseline engineering changes	Supportability assessment Rpt Contribution
Analyze reports of failures and mishap incidents	Operational Assessments Contributions
T&E / Demo, Reports	Transition & Fielding Docs
Software evaluations of tech baseline docs, tech orders, operations manuals	

Software Engineers' Contributions to Program and Project Management

Each SMC program defines their business model and approach structure based primarily on their program objectives, program and technical challenges, organizational structure, as well as program and engineering planning, for example SWAMP, SEP, LCMP. Software Engineer also supports Integrated Baseline Review (IBR).

The Software Engineer develops and implements the software engineering program planning to achieve Program Office software engineering objectives and requirements. The planning should scope the software program to define key tasks and functions to be performed and products to be developed: timing of tasks, task outputs, resources (skills, tools, equipment, and completion criteria). The Software Engineer plans tasks to integrate software development activities within the Program Office, between Contractors and stakeholders. The Software Engineer plans the tasks to establish and manage software production; conduct review forums; support Systems Engineering and Integration (SE&I) activities, risk management, integration, and system modifications; coordinate the software engineering planning with SMC Staff Software Engineering office, integrate software engineering planning with other functional and acquisition plans (i.e. SWAMP, SEP, ASP, LCMP).

Execution of the Software Engineer planning is typically defined through a program office Operating Instruction which implements SMC and higher level instructions, policies, and directives. The Software Engineer provides full support to define the program and technical objectives where software challenges and risks are known or anticipated. The Software Engineer assists to establish the business model, develop program planning and schedules, and define and implement program processes. The Software Engineer ensures the software components of the program are appropriately represented in the program plans, program schedules, work breakdown schedules, cost estimates. The Software Engineer also reports their technical performance and progress. The Software Engineer shares in the risk management responsibilities to identify, assess, and propose mitigating actions of software related risks. They also support the program manager's problem identification, resolution, and decision-making processes.

The Software Engineer contributes to the development of the program management products identified in the Table.

SMC Program Management Products
PMD
SWAMP, SEP, IMP, IMS, WBS
Decision-making & problem solving inputs
Technical progression and issues reporting
Software Cost Estimate, CARDs
Earned Value Management (EVM)
Processes (OIs)
Risk Management Inputs

Appendix C – Integrated Logistics Support

DoDD 5000.01 requires Program Managers to: *"develop and implement performance-based logistics strategies that optimize total system availability while minimizing cost and logistics footprint." Further,* within the Defense Acquisition Management System, DoDD 5000.01 requires that: *"Planning for Operation and Support and the estimation of total ownership costs shall begin as early as possible. Supportability, a key component of performance, shall be considered throughout the system life cycle."*

The PM, as the life-cycle manager, is responsible for accomplishing program objectives across the life cycle, including the operating & support (O&S) phase. Employing performance-based life-cycle product support tied to sustainment metrics is the overarching Department of Defense (DoD) concept for providing materiel readiness to the User. the Program Manager (PM), Product Support Manager (PSM) and Life-Cycle Logisticians can influence the design and provide effective, timely product support capability to achieve the system's materiel readiness and sustain operational capability. This can be effected by placing the emphasis on integrating life-cycle management principles, using performance-based life-cycle product support strategies, combining Systems Engineering processes resulting in materiel readiness at optimal life-cycle cost (LCC) through reduction of frequency, duration, and related costs of availability degrading events, reducing the system's manpower and logistics footprint.

The SMC Program Office Logistician plans and executes the essential Logistics Engineering, acquisition, and management efforts in an integrated and effective manner to ensure that each Integrated Logistics Support (ILS) contribution is timely, adequate, consistent, and compliant. The Logistician ensures that their engineering contributions are channeled through the Systems Engineering *Analyses and Control* activity. The Logistician also supports the Program Office engineering analysis and control efforts as well as technical and program management decision making.

Applicable Governance, Standards, and Guidance

Policy, directives, and instructions that mandate ILS related program requirements are included in a wide range of mandates including those providing requirements for acquisition, reliability and maintainability, T&E, software, Systems Engineering, and others. Table 5 below identifies the significant governance, standards, and guidance which generally require SMC compliance with ILS requirements and objectives.

Table 5 Governance, standards, and guidance that shape the Integrated Logistics Support Engineering discipline

Document No	Governance Title	Issue
DoDI 5000.01	The Defense Acquisition System	20 Nov 07
DoDI 5000.02	Operation of the Defense Acquisition System	08 Dec 08
CJCSI 3170.01G	Joint Capabilities Integration and Development system	01 Mar 09
DoDI 3020.37	Continuation of Essential DoD Contractor Services During Crises	26 Jan 96
DoDI 4151.19	Serialized Item Management (SIM) for Materiel Maintenance	26 Dec 06
DoDI 4151.20	Depot Maintenance Core Capabilities Determination Process	05 Jan 07
DoDI 4151.22	Condition Based Maintenance Plus (CBM+) for Materiel Maintenance	02 Dec 07
DoDI 5000.67	Prevention & Mitigation of Corrosion on DoD Military Equipment & Infrastructure	01 Feb 10

DoDI 5200.39	Critical Program Information (CPI) Protection Within the Department of Defense	16 Jul 08
DoDI 8320.04	Item Unique Identification (IUID) Standards for Tangible Personal Property	16 Jun 08
DoDD 2010.9	Acquisition & Cross-Servicing Agreements	24 Nov 03
DoDD 4140.1	Supply Chain Materiel Management Policy	22 Apr 04
DoDD 4151.18	Maintenance of Military Materiel.	31 Mar 04
AFI 10-604	Capabilities Based Planning	10 May 06
AFI 21-133(I)	Joint Depot Maintenance (JDM) Program	31 Mar 99
AFI 21-108	Maintenance Management of Space Systems	25 Jul 94
AFI 21-118	Improving Air and Space Equipment RAM	02 Oct 03
AFI 63-1201	Life Cycle Systems Engineering	23 Jul 07
AFSPCI 10-604	Space Operations Weapon System Management	01 Oct 07
AFSPCI 10-1204	Satellite Operations	01 Jun 06
SMCI 62-001	Reliability And Maintainability	11 Apr 07
Document No	**Standards Title**	**Issue**
MIL-PRF-49506	Logistics Management Information	11 Nov 96
MIL-STD-1367-A	Packing, Handling, Storage & Transportability Program Reqmts for Systems & Equipments	2 Oct 89
MIL-STD-2073-1E	Standard Practice for Military Packaging	23 May 08
TM-86-01/T, Rev M	AF Technical Manual Contract Reqmts (TMCR)	01 Aug 06
MIL-PRF-29612B	Training Data Products	31 Aug 01
MIL-STD-130N	Identification Marking of US Military Property	17 Dec 07
Document No	**Guidance Title**	**Issue**
DoDR 4140.1-R	DoD Supply Chain Materiel Management	23 May 03
DoDR 4500.9-R	Defense Transportation Regulation, Part 2 Cargo	07 Apr 10
DoDR 4500.9-R	Defense Transportation Regulation, Part 3 Mobility	28 Jan 10
SAE JA1011	Evaluation Criteria - Reliability-Centered Maintenance (RCM) Processes	01 Aug 09
SAE JA1012	A Guide to the Reliability-Centered Maintenance (RCM) Standard	01 Jan 02
DoDM 5000.4	DoD Cost Analysis Guidance & Procedures	11 Dec 92
DoDM 5100.76-M	Safeguarding Conventional Arms, Ammunition, & Explosives (AA&E)	20 May 10
DoDM 4160.21-M-1	Defense Demilitarization Manual	15 Feb 95
DAU DAG	Defense Acquisition Guidebook, Chapter 5, Life-Cycle Logistics	
MIL-P-24534A	Specification: Planned Maintenance System	21 Mar 91
Supportability Guide	A Guide to Increased Reliability & Reduced Logistics Footprint	24 Oct 03
CPATS	Critical Process Assessment Tool - Logistics	14 Aug 98

ILS Logisticians' Contributions to the Acquisition Life Cycle Framework

The DoD acquisition life cycle is defined by DoDI 5000.02. ILS contributions over this life cycle are best represented within the phases of the Defense Acquisition Management System. Figure 6 provides the acquisition life cycle framework within which Logisticians perform as well as the products that the Logisticians must develop or contribute to their development. SMC Program Offices establish and implement ILS program strategies and objectives consistent with the tenets of appropriate policies, SMC acquisition objectives, and program objectives.

The Program Office then develops, attains approval for, and implements ILS planning through a Life Cycle Management Plan (LCMP), the Systems Engineering Plan (SEP) and higher level integrated planning (e.g., IMP) in accordance with current DoD policy. This planning will be firmly based on program and technical objectives, strategies, DoD mandates, and instructions. In addition the Logistics Engineer/Logistician prepares the Transition Support Plan (TSP) to establish planning and implementation requirements associated with the production contracts from the Developing Agency to the Using Agency. The Logistics POC also collaborates on the TOA (developed by A5 Turnover Agreement (TOA) to assist the Program Office to prepare for all the events and documentation needed for turnover.

An effective ILS program supports all of the major acquisition activities through the full system life cycle. Effective sustainment begins with the supportability analysis to form CDD requirements for each supportability parameter to be designed, developed, or procured as proven commercial technology. It is these analysis-driven supportability parameters, once integrated through Systems Engineering with all other technical parameters, which drive deployed system operational availability, sustainment effectiveness, and operator ownership affordability.

All Phases - The Life Cycle Logistician considers each ILS support element, defining supportability objectives.
Maintenance Planning: Establishes and documents maintenance concepts and requirements.
Manpower and Personnel: Identifies personnel skills, grades and quantity required to support operation and maintenance of system.
Supply Support: Determines requirements to acquire and manage spares and repair parts.
Support Equipment: Identifies all equipment required to support operation and maintenance of the system.
Technical Data: Ensures availability of scientific and technical information used to support systems acquisition, operations and sustainment.
Training and Training Support: Determines requirements to acquire and support training devices and conduct training of the user community (i.e., operators, maintainers, support personnel, etc).
Computer Resources Support: Identifies facilities, hardware, software and support tools to operate and support embedded computer systems.
Facilities: Identify real property required to support system operations and maintenance.
Packaging, Handling, Storage and Transportation: Identifies designs and methods to ensure the system is preserved, packed, stored, handled and transported properly.
Design Interface: Documents relationships of logistics-related design parameters to readiness and support resources requirements; influence design for supportability.

The ILS planning sufficiently defines the ILS program to achieve the ILS and overall program objectives and requirements; specifies tasks and functions to be performed, timing of tasks, resources required, and products to be developed; forms the basis for the development of the program ILS Operating Instruction (OI). The ILS planning is then reflected appropriately in the WBS, IMS, and other program documents that address ILS related elements. The ILS planning is executed concurrently with the Program Office OI that documents the process to perform, control, and integrate all ILS engineering and management activities for each phase of acquisition. The SMC Program Office ILS planning (usually contained in the LCMP, SEP and the detailed ILS program planning) and OI is based upon the appropriate program-approved life cycle. SMC Program Offices appoint establish and implement ILS program strategies and objectives consistent with the tenets of appropriate policies, SMC acquisition objectives, and program objectives.

1. **Materiel Solution Analysis.** During this phase the ILS Engineer provides inputs to and supports most program acquisition activities to include the development of the acquisition strategy, inputs to the cost estimates, solicitation/RFP development for Contractor studies, and proposal evaluation activities. The ILS Engineer focus is on identifying initial concept and critical product support capability requirements. Affordable operational effectiveness is the overarching sustainment objective that should be considered during the JCIDS process. The ILS Engineer supports mission, operational, and system concept definition and planning to mature enabling technologies. The conclusion of this phase produces the initial acquisition strategy (including the sustainment strategy), a contractual document required to continue into the Technology Development Phase and includes initial support and maintenance concepts, LCC, and manpower estimates for the system concept. The ILS Engineer also contributes to the development of the MSA Phase acquisition products.

MSA Phase – SMC Acquisition Products
PMD
AOA, ASP, ICD, TDS, DMS, TES
LC Cost Estimate
RFP inputs (ILS, Quality, RAM mission/operational/ system requirements; Assessment requirements; High level reliability formulations
APB, CCA
SSP
SEP, LCMP
Draft CDD, Initial Spt & Maint Concepts

2. **Technology Development.** The ILS Engineer provides inputs to and supports all program acquisition activities to include the development of the acquisition strategy and development of the Cost Analysis Requirements Description (CARD), solicitation/RFP development and proposal evaluation activities. The ILS Engineer identifies other contract requirements such as incentives/warranty programs and test & demo requirements to meet ILS objectives. The ILS Engineer also contributes to the development and updates to the TD Phase acquisition products.

TD Phase – SMC Acquisition Products
Updates to AOA, ASP, TDS, DMS
LC Cost Estimate Update / CARD Development
RFP: ILS objectives in the SOO; ILS related tasks in SOW, ILS data products in CDRLs; SMC ILS standards tailored
SSP: evaluation criteria for ILS
APB: ILS objectives & related concept descriptions
Detailed ILS planning, SEP, LCMP, TEMP
Draft CDD, Initial Spt & Maint Concepts, Spt Strategy
Sys Perf Specs, PDR, TEMP, ISP,
Core Log Analysis/Source of Repair Analysis
Prelim Maint Plans, Affordability Assessment

3. **Engineering & Manufacturing Development.** The ILS Engineer provides inputs to and supports all program acquisition activities to include updates to the acquisition strategy and updates to the CARD. The ILS Engineer supports the solicitation/RFP development and proposal evaluation activities which include providing the technical inputs including technical requirements, compliance standards, engineering approaches, incentives, and warranty programs to meet program objectives. The ILS Engineer identifies other contract requirements such as incentives/warranty programs and prototype and engineering qualification unit supportability related test & requirements to meet ILS objectives. The ILS Engineer also contributes to the development and updates to the EMD Phase acquisition products.

EMD Phase – SMC Acquisition Products
Updates to APB, ASP, ICD, CDD, TDS, DMS
CARD update, PDR, DT&E Rpt,
RFP: ILS objectives in the SOO; ILS related tasks in SOW, ILS data products in CDRLs; SMC- ILS standards - tailored
SSP: evaluation criteria for RAM
APB: ILS objectives & related concept descriptions
Detailed ILS planning, SEP, LCMP, TEMP updates
Capability Production Doc, Approved Maint Plans

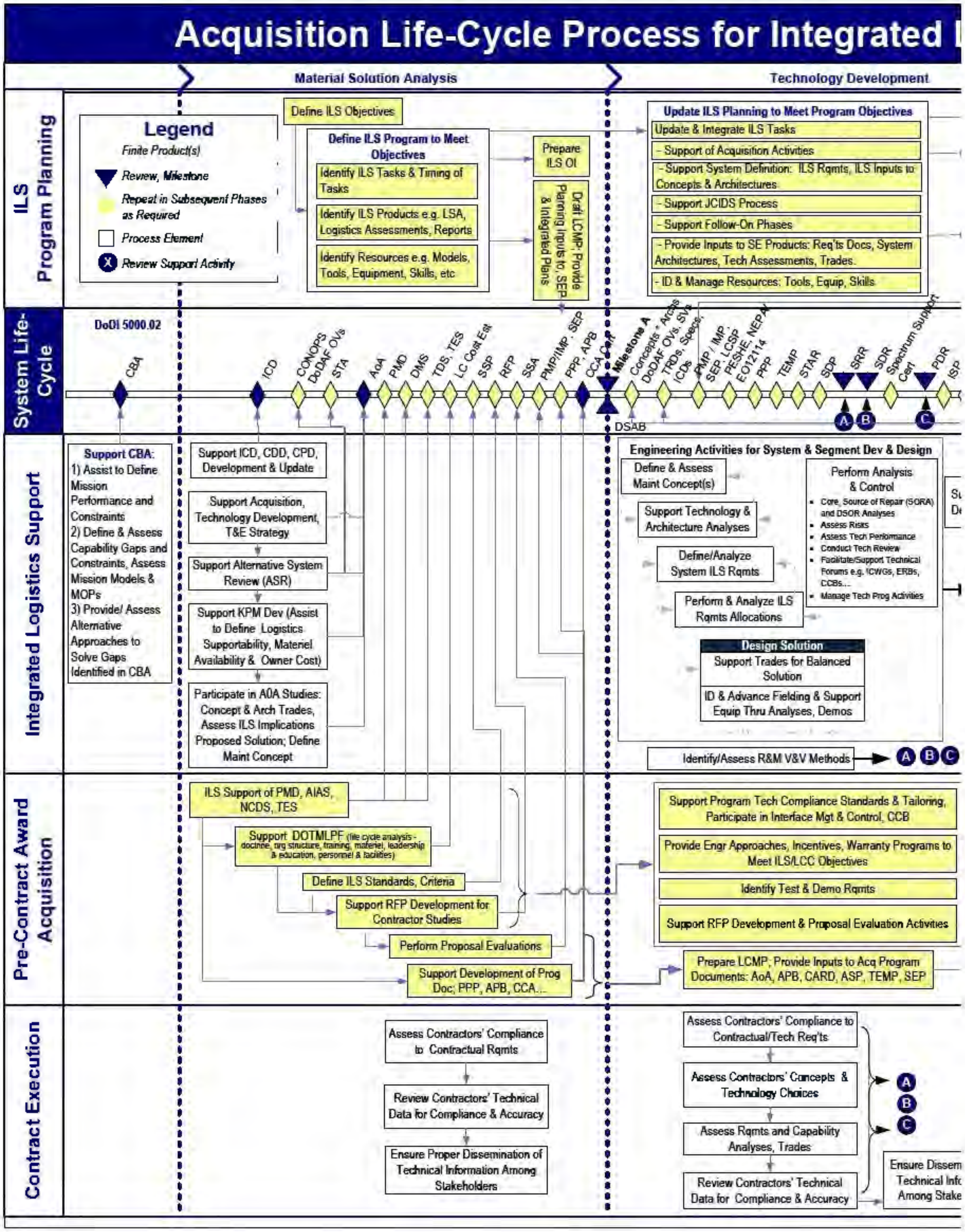
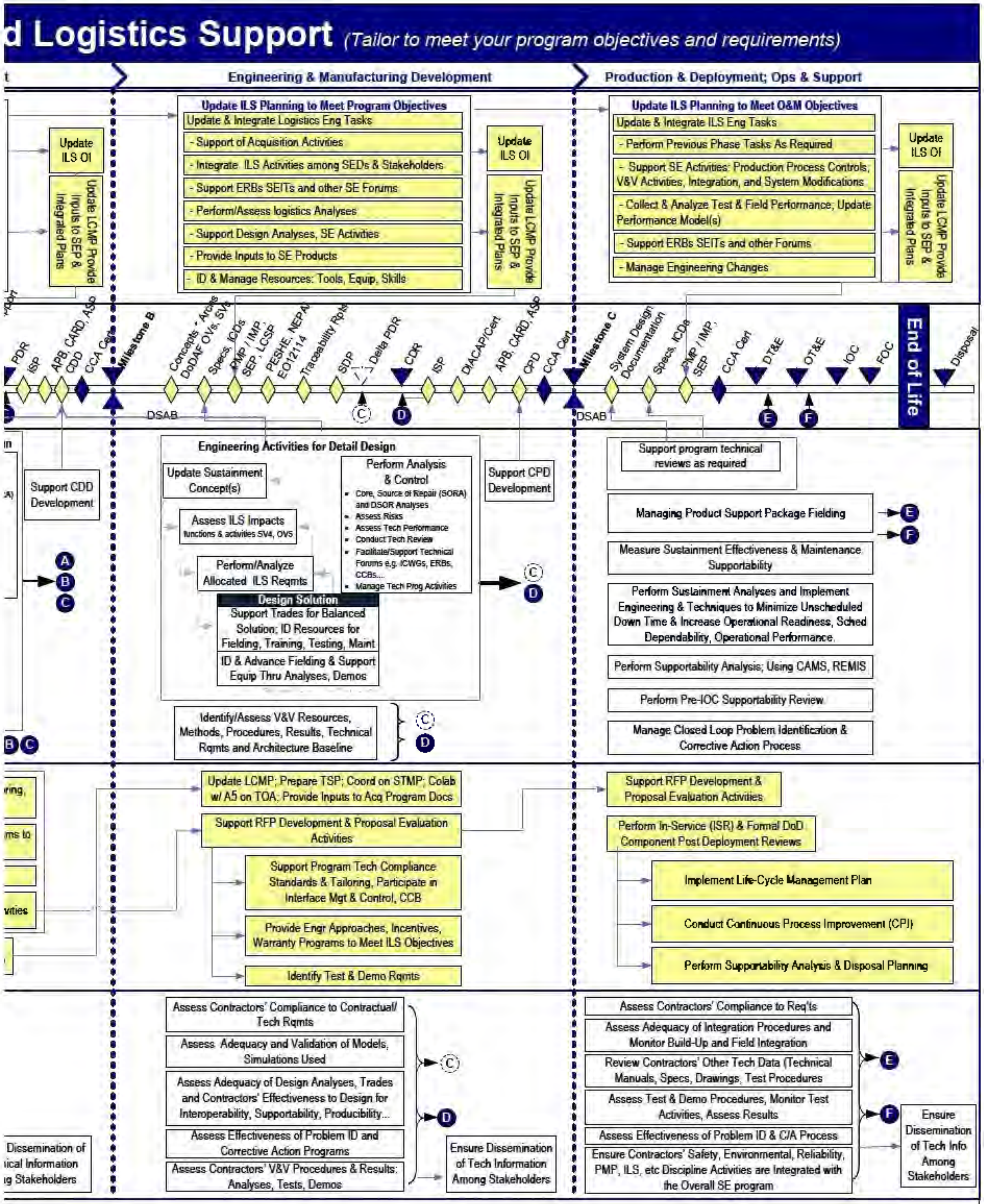


Figure 6 Acquisition life cycle process for SMC Logistics Engineering



d Logistics Support (Tailor to meet your program objectives and requirements)
Engineering & Manufacturing Development
Production & Deployment; Ops & Support
Update ILS OI
Update LCMP Provide Inputs to SEP & Integrated Plans
Update ILS Planning to Meet Program Objectives
Update & Integrate Logistics Eng Tasks
- Support of Acquisition Activities
- Integrate ILS Activities among SEDs & Stakeholders
- Support ERBs SEITs and other SE Forums
- Perform/Assess logistics Analyses
- Support Design Analyses, SE Activities
- Provide Inputs to SE Products
- ID & Manage Resources: Tools, Equip, Skills
Update ILS OI
Update LCMP Provide Inputs to SEP & Integrated Plans
Update ILS Planning to Meet O&M Objectives
Update & Integrate ILS Eng Tasks
- Perform Previous Phase Tasks As Required
- Support SE Activities: Production Process Controls, V&V Activities, Integration, and System Modifications
- Collect & Analyze Test & Field Performance; Update Performance Model(s)
- Support ERBs SEITs and other Forums
- Manage Engineering Changes
Update ILS OI
Update LCMP Provide Inputs to SEP & Integrated Plans
PDR
ISP
APB, CARD, ASP
CDD
CCA Cert
Milestone B
Concepts - Archs
DoDAF OVs, SVs
Specs, ICDs
PMP / IMP, SEP, LCSP
PESHE, NEPA EO12114
Traceability Rpts
SDP
Delta PDR
CDR
ISP
DIACAP/Cert
APB, CARD, ASP
CPD
CCA Cert
Milestone C
System Design Documentation
Specs, ICDs
PMP / IMP, SEP
CCA Cert
DT&E
OT&E
IOC
FOC
Disposal
End of Life
DSAB
DSAB
C
D
E
F
Support CDD Development
A
B
C
Engineering Activities for Detail Design
Update Sustainment Concept(s)
Assess ILS Impacts functions & activities SV4, OVS
Perform/Analyze Allocated ILS Reqmts
Perform Analysis & Control
Core, Source of Repair (SORA) and DSOR Analyses
Assess Risks
Assess Tech Performance
Conduct Tech Review
Facilitate/Support Technical Forums e.g. ICWGs, ERBs, CCBs...
Manage Tech Prog Activities
Design Solution
Support Trades for Balanced Solution; ID Resources for Fielding, Training, Testing, Maint
ID & Advance Fielding & Support Equip Thru Analyses, Demos
Support CPD Development
C
D
Identify/Assess V&V Resources, Methods, Procedures, Results, Technical Rqmts and Architecture Baseline
C
D
B C
Support program technical reviews as required
Managing Product Support Package Fielding
E
F
Measure Sustainment Effectiveness & Maintenance Supportability
Perform Sustainment Analyses and Implement Engineering & Techniques to Minimize Unscheduled Down Time & Increase Operational Readiness, Sched Dependability, Operational Performance.
Perform Supportability Analysis; Using CAMS, REMIS
Perform Pre-IOC Supportability Review
Manage Closed Loop Problem Identification & Corrective Action Process
Update LCMP; Prepare TSP; Coord on STMP; Colab w/ A5 on TOA; Provide Inputs to Acq Program Docs
Support RFP Development & Proposal Evaluation Activities
Support Program Tech Compliance Standards & Tailoring, Participate in Interface Mgt & Control, CCB
Provide Engr Approaches, Incentives, Warranty Programs to Meet ILS Objectives
Identify Test & Demo Rqmts
Support RFP Development & Proposal Evaluation Activities
Perform In-Service (ISR) & Formal DoD Component Post Deployment Reviews
Implement Life-Cycle Management Plan
Conduct Continuous Process Improvement (CPI)
Perform Supportability Analysis & Disposal Planning
Assess Contractors' Compliance to Contractual/ Tech Rqmts
Assess Adequacy and Validation of Models, Simulations Used
Assess Adequacy of Design Analyses, Trades and Contractors' Effectiveness to Design for Interoperability, Supportability, Producibility...
Assess Effectiveness of Problem ID and Corrective Action Programs
Assess Contractors' V&V Procedures & Results: Analyses, Tests, Demos
C
D
Ensure Dissemination of Tech Information Among Stakeholders
Dissemination of ical Information g Stakeholders
Assess Contractors' Compliance to Req'ts
Assess Adequacy of Integration Procedures and Monitor Build-Up and Field Integration
Review Contractors' Other Tech Data (Technical Manuals, Specs, Drawings, Test Procedures
Assess Test & Demo Procedures, Monitor Test Activities, Assess Results
Assess Effectiveness of Problem ID & C/A Process
Ensure Contractors' Safety, Environmental, Reliability, PMP, ILS, etc Discipline Activities are Integrated with the Overall SE program
E
F
Ensure Dissemination of Tech Info Among Stakeholders

4. **Production & Deployment.** The ILS Engineer provides inputs to and supports all program acquisition activities to include updates to the acquisition strategy and updates to the CARD. The ILS Engineer supports the solicitation/RFP development and proposal evaluation activities. The ILS Engineer identifies other contract requirements: incentives/warranty programs; production and field test & demo requirements; field performance and sustainment analyses to meet ILS objectives.

P&D Phase – SMC Acquisition Products
Updates to ASP, TDS, DMS
RFP: ILS objectives in the SOO; ILS related tasks in SOW, ILS data products in CDRLs; SMC ILS standards tailored
SSP: evaluation criteria for RAM
Detailed ILS planning, SEP, LCMP, TEMP updates
CARD update, PCA Rpt, Info Supportability Cert

5. **Operations & Support.** In the total life-cycle systems management concept, providing user support and managing the demilitarization and/or disposal of old systems are the PM's responsibilities. During this phase, the PM is the system focal point to the User. The PM and his/her assigned ILS POC focuses on supporting the User by executing the sustainment program and on making adjustments based on effectiveness and operating conditions using Systems Engineering principles. The ILS Logistician consults with accountable military department logistics officials prior to making depot maintenance source of support decisions to ensure the DoD Component depot maintenance 50 percent limitation statutory requirement is being met. The PM and ILS Logistician coordinate with DoD Component logistics activities and DLA, as appropriate, to identify and apply applicable demilitarization requirements necessary to eliminate the functional or military capabilities of assets and determine property disposal requirements for system equipment, support assets, and by-products.

O&S Phase – SMC Acquisition Products
Product Spt Integrator/Provider performance Rpt
Product Improvement Rpt
Configuration Control Rpt
System Supply Mgt
LCMP
Cost/Benefit Analysis
Replacement Planning
System Supportability Assessment
Disposal Planning

ILS Engineers' Contributions to the Engineering Life Cycle Framework

Relationship to the SE Organization

Systems Engineers manage the engineering process and activities depicted in Figure 3 while the ILS Engineer contributes to this process. ILS engineers support concept and architecture development and analyses; modeling and simulation efforts; technology studies. The ILS engineer develops/derives their requirements and supports the requirements analyses and allocations process. They also participate in technical studies and technical solutions trades when logistics elements are a factor. They provide design analyses contributions to determine and collaborate with the RAM Engineer to adjust reliability allocations, update reliability predictions, and ensure confidence in attaining ILS requirements through analyses, demo, and test.

Relationship to other SEDs

In performing the management and control function, the SE effectively integrates all engineering functions through the full system life cycle. The ILS Engineer ensures their technical information is current and appropriately applied through systematic control, collaboration and sharing across the organization. All elements of ILS are developed in concert with the system engineering effort and with each other. Tradeoffs are required between elements in order to determine balanced solutions and to acquire a system that is: affordable (lowest life cycle cost), operable, supportable, sustainable, transportable, and environmentally sound. ILS developmental efforts are typically categorized into the following 10 elements:

1. Reliability Engineering, Maintainability Engineering and Maintenance (preventive, predictive and corrective) Planning
2. Supply (Spare part) Support (e.g. AECMA 2000M standard) and acquire resources
3. Support and Test Equipment/Equipment Support
4. Manpower and Personnel
5. Training and Training Support
6. Technical Data / Publications
7. Computer Resources Support
8. Facilities
9. Packaging, Handling, Storage, and Transportation (PHS&T)
10. Design Interface

The logistics support analyses must be timed and applied by the other Specialty Engineers to perform their unique contributions, and must be provided to technical and program management for decision making.
The ILS Engineer SED's relationship to other SEDs is summarized in Figure 1. The ILS Engineer also works closely with the System Engineers performing deployment, integration and verification and validation planning and execution. The Logistics Engineer works closely with the Reliability Engineer performing maintenance and sustainment analyses. The Logistics Engineer aligns closely with the Quality Assurance and Quality Engineer to ensure delivery and deployment of reliable products through controlled and predictable quality levels during production, handling, storage, packaging, and transportation.

ILS Functions Requiring Tools
Operations & Sustainment Modeling
RAM Analyses & Allocations
Experiment Design, Growth, and Life Data Analysis
Reliability Centered Maintenance
FMEA, LSA, LSAR
Training

Tools Selection & Use

The ILS Engineer considers effectiveness and efficiencies gained by selecting and using the best choice of ILS tools considering the ILS tool requirements for LSA, logistics database development and management, information sharing, automated data exchanges with other tools, and other considerations.

Engineering Activities and Products over the Life Cycle

The following subsections summarize the ILS Engineer's contributions to engineering activities and technical products by DOD acquisition phase. Refer to SMC ILS guidance for detailed activities, requirements and guidance.

1. **Materiel Solution Analysis.** During this phase the ILS Engineer may provide inputs to and support the Capabilities Based Assessment process and the JCIDS process. The ILS Engineer also contributes to the development of the MSA technical products.

MSA Phase – Technical Products Required	
SMC ILS Technical Products	**ILS Contributions to Other Organizations' Products**
High level reliability analysis	Operational Concepts
ILS inputs and factors for concept, architecture, technology studies, and trades	AoA Studies
System ILS Req'ts (draft)	Initial Capabilities Doc (ICD) Dev
Roadmap inputs	DoDAF CVs, OVs

2. **Technology Development.** During this phase the ILS Engineer continues to provide inputs to and supports the JCIDS process. The ILS Engineer also supports all the engineering activities highlighted within the box titled *Engineering Activities for System & Segment Development & Design* Figure 6 to commence system definition and development. ILS Engineer develops and contributes to development of the TD Phase technical products.

TD Phase – Technical Products Required	
SMC ILS Technical Products	**ILS Contributions to Other Organizations' Products**
Inputs to System Concepts	Operational Concepts
Factors for Studies/ Trades	Operational Assessments
ILS Tech Req'ts, TRD, SRD, Specifications, ICDs, Standards Selection/ Tailor	Capabilities Development Doc (CDD)
ILS inputs to ISP	DoDAF CVs, OVs
ILS Analyses Rpts	

The ILS Engineer focus is on developing preliminary design (down to subsystem/equipment level), reducing integration and manufacturing risk, and, from a sustainment perspective, optimizing system sustainment through designed-in criteria to help ensure sustainability, with particular attention to reducing the logistics footprint, implementing human systems integration, and designing for support to help ensure life-cycle affordability. Detailed plans for organizing to manage implementation of the product support package begin in this phase. The support concept and design-to requirements to design the product support package are defined. Technology demonstrations and prototyping are conducted, determining mature, affordable technologies to be included in the system and support system designs. The demonstrations results and analysis refine requirements and the LCC estimate, narrow the ranges of all program metrics, and increase confidence the values can be met at an affordable cost. ILS Engineer emphasis is on maturing the enabling technologies for achievement of supportability objectives. Achievable performance evaluations, given demonstrated technologies, on refining supportability objectives, and identifying constraints, system or supply chain, to achieve operational readiness or mission effectiveness are completed.

3. **Engineering & Manufacturing Development.** ILS Engineer continues to provide inputs to and supports the JCIDS process. The ILS Engineer supports all the engineering activities highlighted within the box titled *Engineering Activities for Detailed Design* Figure 6 to commence detailed systems definition and development. The ILS Engineer along with the RAM Engineer establishes a closed-loop failure reporting system across contractors, stakeholders and other failure reporting/analysis & corrective action contributors. The ILS Engineer works with the Reliability Engineer to establish JRMET to assist in collecting, analyzing, and categorizing ILS data during DT&E. The ILS Engineer inputs to and supports the JCIDS process. ILS Engineer develops and contributes to the development of the EMD Phase technical products. In this Phase, the ILS Engineer focus is on development of detailed integrated design to ensure producibility and operational supportability by producing detailed manufacturing designs. Prototyping and analysis applied prior to this phase provides a design based on a mature technology, achievable within cost, schedule and sustainment constraints. Reduction of the logistics footprint; implementing human systems integration; designing for supportability; and ensuring affordability, integration with the supply chain, interoperability, and safety are used to refine the performance-based support concept and strategy, with associated requirements, and identify potential support providers. Developing the requirements for the long-term performance-based support concept and the initial product support package allows refinement of life-cycle management documents and analyses using iterative Systems Engineering analyses and developmental test results. Critical sustainment metrics are also refined and incentives developed for eventual performance-based support contracts and/or performance-based agreements. Stakeholders are identified and included in Integrated Product/Process Team (IPT) processes to build an early understanding of and buy-in for sustainment requirements and objectives. The support concept is refined and potential support providers identified. Incentives to design for support and cost-effectiveness, are identified and included in the support strategy.

EMD Phase – Technical Products Required	
SMC ILS Technical Products	**ILS Contributions to Other Organizations' Products**
Update System Concept	Operational Concepts
Technical Studies/ Trades	Operational Assessments
System Tech Req'ts, TRD, SRD, Spec, ICDs; RAM allocations	Capabilities Production Doc (CPD)
Inputs to system, production, fielding, sustain design docs	
ILS inputs to ISP	DoDAF CVs, OVs
RAM Analyses Rpts, RBD, models, predictions	
Test, Demo reports	

4. **Production & Deployment.** The ILS Engineer continues to provide inputs to and supports the JCIDS process. The activities of ILS during this phase are extensive. Refer to the ILS guidance for activities and products typically required during each phase. The ILS Engineer develops and contributes to the development of the Production & Deployment Phase technical products.

P&D Phase – Technical Products Required	
SMC ILS Technical Products	**ILS Contributions to Other Organizations' Products**
Inputs tech baseline engineering changes	Supportability Analyses Rpt
Analyses of production quality reports and test reports	Operational Assessments
Transition & Fielding Docs	
ILS Analyses Rpts; Reliability And Maintainability Information System Assessments (REMIS)	
V&V / T&E Reports	

During this phase, the ILS Engineer's emphasis is on finalizing equipment product support packages/ maintenance plans, managing and deploying the initial sustainment capabilities, and demonstrating the product support capabilities and effectiveness. Once demonstrated, fielding and implementing sustainment capabilities provide users the capabilities identified in requirements documents. Measuring the product sustainment package's effectiveness (including the associated supply chain) confirms user support required to sustain the system within the budget provided is achieved, while informing senior leadership the consequences and impacts on the Sustainment KPP/KSAs of budget constraints. Coordinating with the contractors, supply chain and operators to ensure each understands and is implementing responsibilities in accordance with the LCMP in an integrated fashion. Monitoring any changes to the design, operational environment and supply chain and adjusting the logistics elements within the product support package as required. Searching for improvements to reduce the product support package cost. Reliability of contractor cost and performance data is verified by monitoring contracts.

5. **Operations & Support.** ILS Engineer continues to provide inputs to and supports the JCIDS process. The activities of ILS during this phase are extensive. Refer to the SMC-G-001 Life Cycle Systems Engineering, Section 4.3.5, Guide for ILS Engineer activities and products typically required. The ILS Engineer develops and contributes to the development of the O&S Phase technical products.

O&S Phase – Technical Products Required	
SMC ILS Technical Products	**ILS Contributions to Other Organizations' Products**
Analyses of production quality reports and test reports	Supportability Analyses Rpt
Transition & Fielding Docs	Operational Assessments

During the O&S Phase, the ILS POC continually assesses the system performance from the User's perspective with existing reporting systems and user feedback to evaluate the fielded system, focusing on performance outcomes meaningful to the user. The data is analyzed, comparing performance expectations against actual performance, root causes of problems identified, and corrective actions developed. Corrective actions are implemented through maintenance plan/requirement changes, process changes, modification of performance-based product support agreements, and/or design changes. The final decision for the corrective action selected will be determined by a balance between many factors, including but not limited to risk/safety, costs, schedule, user requirements and probability of success. The ILS engineer continues to assess sustainability effectiveness of the fielded systems, adjusting the program as required to support the user. Users require readiness and operational effectiveness (i.e., systems accomplishing their missions) according to design parameters in an operational environment. Systems, regardless of application of design for supportability, suffer varying stresses during actual deployment and use. Consequently, the PM should apply the Systems Engineering processes used in acquisition throughout the entire life cycle. The difference is that during this phase actual use data including user feedback, failure reports, and discrepancy reports are used instead of engineering estimates. While acquisition phase activities are important to designing and implementing a successful and affordable sustainment strategy, the ultimate measure of success is supporting the User after the system has been deployed for use. Accordingly, the PM and DoD Components conduct periodic assessments of system support outcomes comparing actual vs. expected levels of performance and support. Assessments require close coordination with the user, support providers and appropriate Systems Engineering IPTs. The PM and ILS engineer conducts periodic In-Service Reviews which include supportability assessments. These assessments may result in disposal of the system following statutory regulations and policy.

ILS Engineers' Contributions to Program and Project Management

Each SMC program defines their business model and approach structure based primarily on their program objectives, program and technical challenges, organizational structure, as well as program and engineering planning (SEP plus detailed ILS planning).

The ILS Engineer develops and implements the ILS program planning to achieve ILS objectives and requirements. The planning defines the ILS tasks and functions to be performed and products to be developed; timing of tasks, task outputs, resources (skills, tools, equipment, and completion criteria. The ILS Engineer plans tasks to integrate ILS activities within the program office, between Contractors and stakeholders. The ILS Engineer plans the tasks to establish and manage ILS activities and forums; support SE&I activities, e.g., production process controls, V&V activities, risk management, integration, and system modifications; Coordinate the ILS planning with SMC ILS OPR, operating commands, supporting commands, and test agencies; integrate ILS planning with other functional and acquisition plans (i.e. SEP, ASP, LCMP).

Execution of the ILS planning is typically defined through an Operating Instruction. The ILS Engineer provides full support to define the program and technical objectives where ILS challenges and risks are known or anticipated. The ILS Engineer assists to establish the business model, develop program planning and schedules, and define and implement program processes. The ILS Engineer ensures the ILS components of the program are appropriately represented in the program plans, program schedules, work breakdown schedules, cost estimates. The ILS Engineer also reports their technical performance and progress. The ILS Engineer shares in the risk management responsibilities to identify, assess, and propose mitigating actions of ILS related risks. They also support the program manager's problem identification, resolution, and decision making processes.

The ILS Engineer contributes to the development of the program management products identified. The SMC Systems Engineering Primer & Handbook describes the role-up and relationships of the engineering detailed plans and schedules, and WBS as well as the integration of ILS with program and project management. ILS develops and contributes to the development of the program management products identified.

SMC Program Management Products
SEP, IMP, IMS, WBS, LCMP
Decision-making & problem solving inputs
Technical progression and issues reporting
LC Cost Estimate (CARDs), Processes (OIs)
Risk Management Inputs

Appendix D – Design Engineering

SMC Program Office Design Engineers at the system, segment and subsystem levels participate throughout the acquisition life cycle process to achieve higher innovation, balanced solutions, reduced system development risks, apply reuse strategies, and reduce cycle time and system costs. For each of the life cycle phases of Figure 7, the SMC design engineer participates to meet the objectives in planning, acquisition, and engineering activities for effective contract execution.

The following paragraphs provide an overview of the SMC Project officer's design engineering roles and responsibility during program execution.

Design Integration

Integrated System Design commences with the entry into the Engineering and Manufacturing Development (EMD) Phase. DoDI 5000.02 defines Integrated System Design as that effort intended to define system and system-of-systems functionality and interfaces, complete hardware and software detailed design, and reduce system-level risk. Integrated System Design includes the establishment of the product baseline for all configuration items. It is commonly understood that SMC contractors perform the actual design of space and missile systems subject to cost, schedule, and performance constraints. The SMC Program Office oversees contractor performance and participates in decisions on system architecture and performance. Design implementation is achieved with concept documentation, architectural artifacts, system requirements documents and interface specifications approved by SMC at major design reviews.

System Level

At the system level, design engineering is a multi-disciplinary process that assesses mission operations, requirements and available technology for spacecraft, payload, C3 and data processing. A typical goal for system design is to produce a balanced design solution meeting all mission needs that provide the lowest life cost. In some cases, schedule and specific technology requirements may be the parameters that drive the system design.

Initially, design engineers support Systems Engineering to define the system architecture. The design engineer participates in trade studies which partition performance and functionality between space and ground segments, meets user needs and disseminates information to interfacing systems. Example space/ground trades are processing requirements (flight vs. ground software), communications links (antenna size, data rates, power), orbits and ground station siting, and data latency allocations. Design engineers validate the flowdown of requirements to lower levels to assure that there is a credible technology solution(s) and that these solutions fully implement the operations concept. SMC participates by conducting reviews, controlling the trade space and decision process.

As the program enters preliminary system design, allocated, and interface design selections may have been determined in prior program concept and technology development phases. Some early phase technology and make-or-buy decisions may constrain space and ground systems designs down to the component level. The impacts of these early design decisions fix costs, constrain technical trades, and often constrain system performance and operations when operational concepts are selected, technology choices are determined, and system level definition documents the system and allocated baseline

As a program evolves, design engineering focuses on the design of segment and subsystems, interfaces, verification, integration and test, and provides support during operations and maintenance. Generally, lead engineers assigned within the Program Office systems engineering organization and lead engineers assigned to system, segment, or product development IPTs fulfill the design engineers' role described below. In addition, SMC design engineers support all program acquisition Milestones, with planning, engineering and programmatic inputs. The following sections discuss design engineering for ground systems and space, respectively.

Ground System

At the ground system level, design engineering validates the flow-down of requirements by demonstrating the availability of implementable solutions and assessing risks for technology development. The ground system design engineer seeks implementation solutions for mission operations, C3, mission data processing, training and operations and maintenance support.

Ground System Subsystem Design

SMC Program Office ground system design engineers may specialize in a particular technology, system component or device as shown in Table 6. Several subsystem engineering disciplines support the design integration activities at the ground segment level.

Table 6 SMC Ground Subsystem Engineering

Design Disciplines	SMC Responsibilities
Spacecraft Operations	• Support Acquisition Process
Mission Planning	• Define operational constraints
Ground Communications	• Support CONOPS development
Personnel Training	• Lead Interface working groups
O&M Support	• Participate in program IPTs
Mission Data Processing	• Control ground trades and decisions
Software Development	• Oversee contractor technical performance
Facilities	• Assess programmatic performance

Ground segment subsystem design engineers are instrumental in planning and implementing technology maturity strategies, assisting definition of technology demonstrations, and performing assessments of technology readiness. The subsystem design engineer also assists in definition of developmental risk mitigations through prototyping, qualification testing, and analyses and is a primary participant in technology studies, design trades, make-or-buy decision process, and a vital contributor to design reviews.

Space System

At the space system level, design engineering validates the flowdown of by demonstrating the availability of implementable solutions and assessing risks for technology development. The space system design engineer seeks implementation solutions for the spacecraft, payloads, communications, and flight software.

Space System Subsystem Design

This SED addresses the SMC Program Office space system design engineer that specializes in a particular technology, system component or device. Most SMC Programs rely heavily upon space system engineers that specialize in design disciplines as shown in Table 7. These design engineers provide insight into the engineering and operational limitations of a design and its adequacy to meet stated requirements and interface constraints.

Table 7 SMC Space Subsystem Design Engineering

Design Discipline	SMC Responsibilities
Payloads	• Support Acquisition Process • Define operational constraints • Support space architecture development • Lead Interface working groups • Participate in program IPTs • Control space trades and decisions • Validate subsystem requirements • Assess technology options • Participate in risk management/mitigation • Monitor and assess V&V activities • Provide authority to proceed to manufacturing • Support system test • Oversee contractor technical performance • Assess programmatic performance
Communications	
Remote Sensing	
Navigation	
Special (SIGINT, lasers, etc.)	
Spacecraft	
Guidance, Navigation	
Attitude Control	
TT&C	
Command & Data Handling	
Power	
Thermal	
Propulsion	
Structures and Mechanisms	

Space segment subsystem design engineers are instrumental in planning and implementing payload and space technology maturity strategies, assisting definition of technology demonstrations, and performing assessments of technology readiness. The space segment subsystem design engineer also assists in definition of developmental risk mitigations through prototyping, qualification testing, and analyses and is a primary participant in technology studies, design trades, make-or-buy decision process, and a vital contributor to design reviews.

Applicable governance, standards, and guidance

Policy, directives, and instructions that mandate SMC design engineering related program requirements are included in a wide range of mandates providing requirements for acquisition, systems engineering, safety, reliability, T&E, Human Systems Integration (HSI), and others. The DoDI 5000.02 Design Engineer related mandates for SMC acquisition programs include ensuring the TDS addresses all known or probable Critical Program Information (CPI) and potential countermeasures such as anti-tamper in the preferred system concept and in the critical technologies and competitive prototypes to inform program protection and design integration during the Technology Development Phase.

DoDI 5000.02 also provides instructions for the realization of system design characteristics that provide producible, reliable and maintainable systems; modular open systems; diagnostics, prognostics, and health management in embedded and off-equipment applications; and system designs that minimize or eliminate system characteristics that require excessive cognitive, physical, or sensory skills; entail extensive training or workload-intensive tasks; result in mission-critical errors; or produce safety or health hazards.

AFI 63-1201, Life Cycle Systems Engineering, restates the 5000.02 requirements and instructs the Program Office Chief Engineer to ensure development of robust design solutions that balance technical and programmatic requirements, including considerations for additional capability increments. Robust designs are relatively insensitive to variations in manufacturing and operational environments, and accommodate change by incorporating attributes of scalability and expandability.

Table 8 below identifies the significant governance, standards, and guidance which require SMC Program Offices to apply effective Design Engineering practices to satisfy mandates.

Table 8 Governance, standards, and guidance that shape the Design Engineering discipline

Document Number	Governance Title	Issue
DoDI 5000.02	Operation of the Defense Acquisition System	08 Dec 08
AFI 63-101	Acquisition and Sustainment Life Cycle Management	22 Mar 11
AFI 63-1201	Life Cycle Systems Engineering	23 Jul 07
Document Number	**Standards Title**	**Issue**
MIL-STD-1542B	EMC Grounding Requirements for Space System Facilities	15 Nov 91
MIL-STD-461F	Electromagnetic Emissions and Susceptibility, Requirements for the Control of Electromagnetic Interference	10 Dec 07
SMC-S-001	Systems Engineering Requirements and Products	12 Jul 10
SMC-S-004	PMP Control Program for Space and Launch Vehicles	13 Jun 08
SMC-S-005	Space Systems – Flight Pressurized Systems	03 Jun 09
SMC-S-006	Solid Rocket Motor Case Design & Test Requirements	13 Jun 08
SMC-S-007	Space Battery	13 Jun 08
SMC-S-008	Electromagnetic Compatibility Requirements For Space Equipment and Systems	13 Jun 08
SMC-S-017	Lithium Ion Battery for Spacecraft Applications	13 Jun 08
SMC-S-018	Lithium Ion Battery for Launch Vehicle Applications	13 Jun 08
SMC-S-020	Technical Requirements for Wiring Harness, Space Vehicle	03 Jun 09
AIAA S-080-1998	Space Systems, Metallic Pressure Vessels, Pressurized Structures, and Pressure Components	01 Jan 98
AIAA S-081A-2006	Space Systems — Composite Overwrapped Pressure Vessels (COPVs)	01 Jan 06
AIAA S-110-2005	Space Systems — Structures, Structural Components, and Structural Assemblies	12 Jul 05
AIAA S-111-2005	Qualification and Quality Requirements for Space-Qualified Solar Cells	01 Jan 05
AIAA S-112-2005	Qualification and Quality Requirements for Space-Qualified Solar Panels	26 Sep 05
AIAA S-113-2005	Criteria for Explosive Systems and Devices Used on Space and Launch Vehicles	10 Nov 05
AIAA S-114-2005	Moving Mechanical Assemblies for Space and Launch Vehicles	30 Jun 05
AIAA S-122-2007	Electrical Power Systems for Unmanned Spacecraft	05 Jan 07
Document Number	**Guidance Title**	**Issue**
SMC-G-001	Systems Engineering Implementation Guide	10 Jun 09

In addition, the SMC requirements for *system* and *system element design solution and validation are provided in* SMC-S-001. SMC guidance to perform common design engineering activities are provided in SMC-G-001 and in this SED.

The Design Engineer understands the relevant requirements inherent in the above directives to facilitate the application and integration of design considerations into the Systems Engineering process. As part of risk reduction, the Design Engineer supports the PM and Lead Systems Engineer / Chief Engineer to effectively implement and manage the design decision process.

Design Engineers' Contributions to Acquisition Life Cycle Framework

The DoD acquisition life cycle is defined by DoDI 5000.02. Design engineering contributions over this life cycle are best represented within each lifecycle phase. Figure 7 provides the acquisition life cycle framework within which Design Engineers perform as well as the products that the Design Engineers develop or contribute to their development. This figure provides the guidance to perform design engineering planning, support pre and post contract award acquisition activities, and perform design engineering across the system lifecycle. SMC Program Offices establish and implement design engineering program strategies and objectives consistent with the tenets of appropriate policies, SMC acquisition objectives, and program objectives. The Program Office develops, attains approval for, and implements design engineering planning into the SEP and higher level integrated planning (e.g., IMP) in accordance with current DoD policy. This planning is firmly based on program and technical objectives, strategies, DoD mandates, and instructions.

Effective design engineering supports all of the major acquisition activities through the full system life cycle. The Design Engineer sufficiently defines the engineering related program planning to satisfy design engineering requirements to achieve overall program objectives. The initial planning specifies tasks and functions to be performed, timing of tasks, resources required, and products to be developed. This planning then forms the basis for the development of the program design engineering (or systems engineering) Operating Instruction (OI). The Design engineering planning and OI are then reflected appropriately in the SEP, WBS, IMS, and other program documents that address design engineering related elements. The Design Engineer delineates the strategy for integrating a solid technical decision process into the overarching systems engineering process. The design engineering planning is executed concurrently with the Program Office Operating Instruction that documents the process to perform, control, and integrate all engineering and management activities for each phase of acquisition.

The SMC Program Office design engineering planning (usually contained in the SEP and the detailed engineering program planning) and process descriptions (OIs) are also based upon the appropriate program-approved life cycle. The following subsections delineate design engineering contributions to acquisition activities and products by DOD acquisition Phase. Also refer to SMC-G-001 for a more complete list of design engineering activities and products that are prepared by the Program office and their Contractors.

MSA Phase – SMC Acquisition Products
ASP, TDS, DMS, TES
LC Cost Estimate
RFP inputs (Design solutions or constraints; concept development / assessment requirements)
APB, SEP, LCMP

1. **Materiel Solution Analysis.** During this phase the Design Engineer provides inputs to and supports most program acquisition activities to include the development of the acquisition strategy and technology development strategy, inputs to the cost estimates, solicitation/RFP development for Contractor studies. The Design Engineer may lead or support evaluations of alternative concept solutions and identification of potential critical technologies and identification of

competitive prototypes. The Design Engineer also contributes to the development of the MSA Phase acquisition products.

2. **Technology Development.** The Design Engineer provides inputs and supports program acquisition activities to include development of the acquisition strategy, updates to the cost model and the Cost Analysis Requirements Document (CARD), solicitation/RFP development and proposal evaluation activities. The Design Engineer also contributes to the development and updates to the TD Phase acquisition products. The Design Engineer may lead or support technology trades, technology advancement strategies, technology readiness assessments, critical technology assessments, and evaluations of alternative solutions. The Design Engineer begins to document technical solutions decisions (see section below Design Engineers' Contributions to Engineering Life Cycle Framework).

TD Phase – SMC Acquisition Products
Updates to ASP, TDS, DMS
LC Cost Estimate Update / CARD Development
RFP: design objectives in the SOO; design related tasks in SOW; SMC- Design standards - tailored
APB: Technology objectives & related concept descriptions
Detailed technology development planning, SEP, LCMP, TEMP

The Design Engineer identifies contract requirements relating to the evolving design and known design constraints, design / prototyping related tasks, test & demo requirements to meet design engineering objectives. The Design Engineer also contributes to the development and updates to other TD Phase acquisition products.

3. **Engineering & Manufacturing Development.** During this phase, Design engineering efforts are concentrated on evolving and analyzing the system design to assure that 1) the design is evolving consistent with the baselined requirements, 2) design qualification is progressing consistent with the contract requirements, 3) the fielded system will conform to regulatory requirements.

EMD Phase – SMC Acquisition Products
Updates to ASP, TDS, DMS
CARD update
RFP: design objectives in the SOO; design related tasks in SOW; SMC- Design standards – tailored; design baseline descriptions
APB: Eng objectives & related concept descriptions
Detailed design related planning, SEP, LCMP, TEMP

The Design Engineer also provides inputs to and supports program acquisition activities to include updates to the acquisition strategy and updates to the cost model to reflect the actual technical solutions baselined and updates to the CARD. The Design Engineer supports the solicitation/RFP development and proposal evaluation activities which include providing the technical inputs including technical requirements, compliance standards, engineering approaches, incentives, and warranty programs to meet program objectives. The Design Engineer identifies other contract requirements as necessary to meet design engineering requirements and program objectives. The Design Engineer also contributes to the development and updates to the EMD Phase acquisition products.

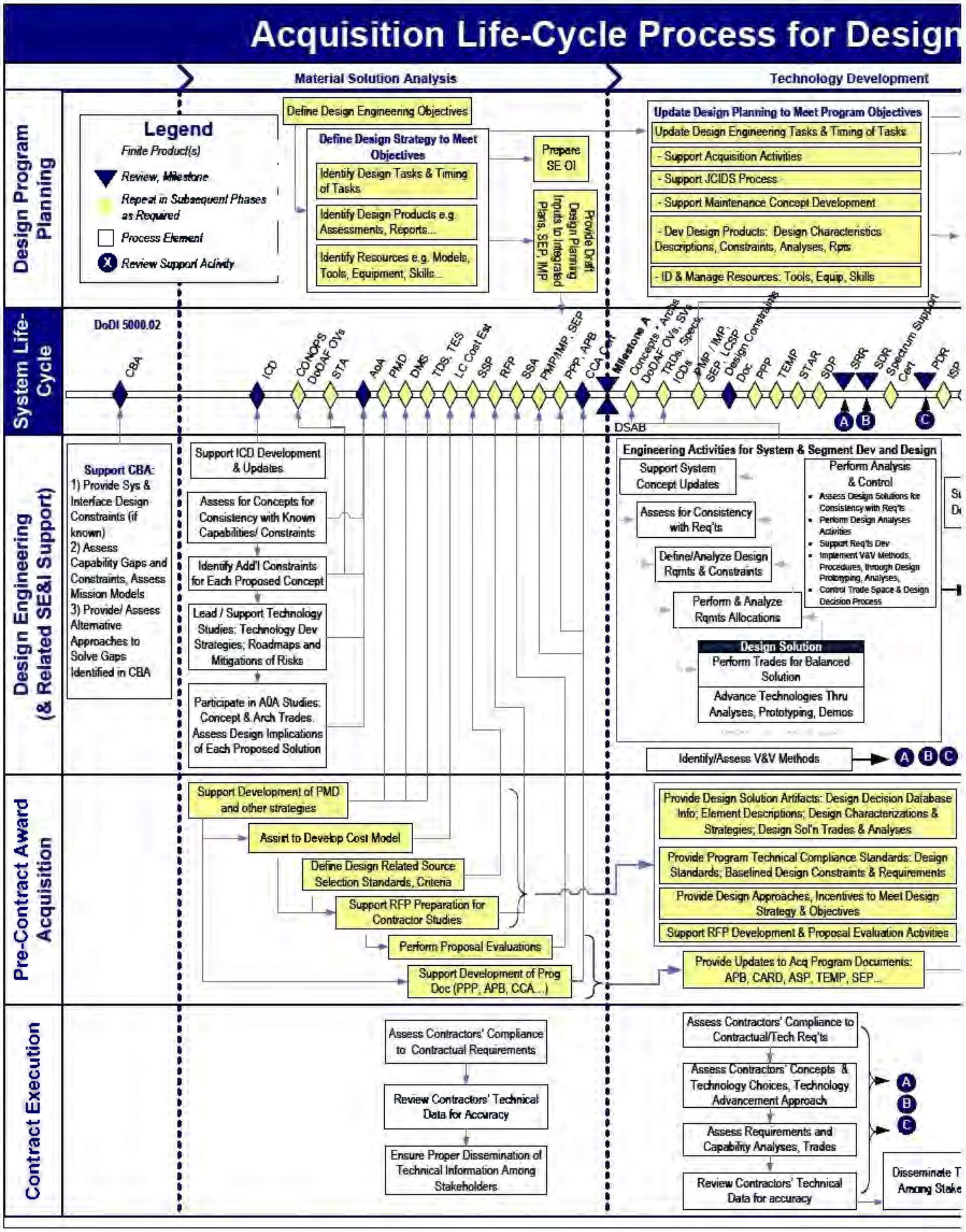
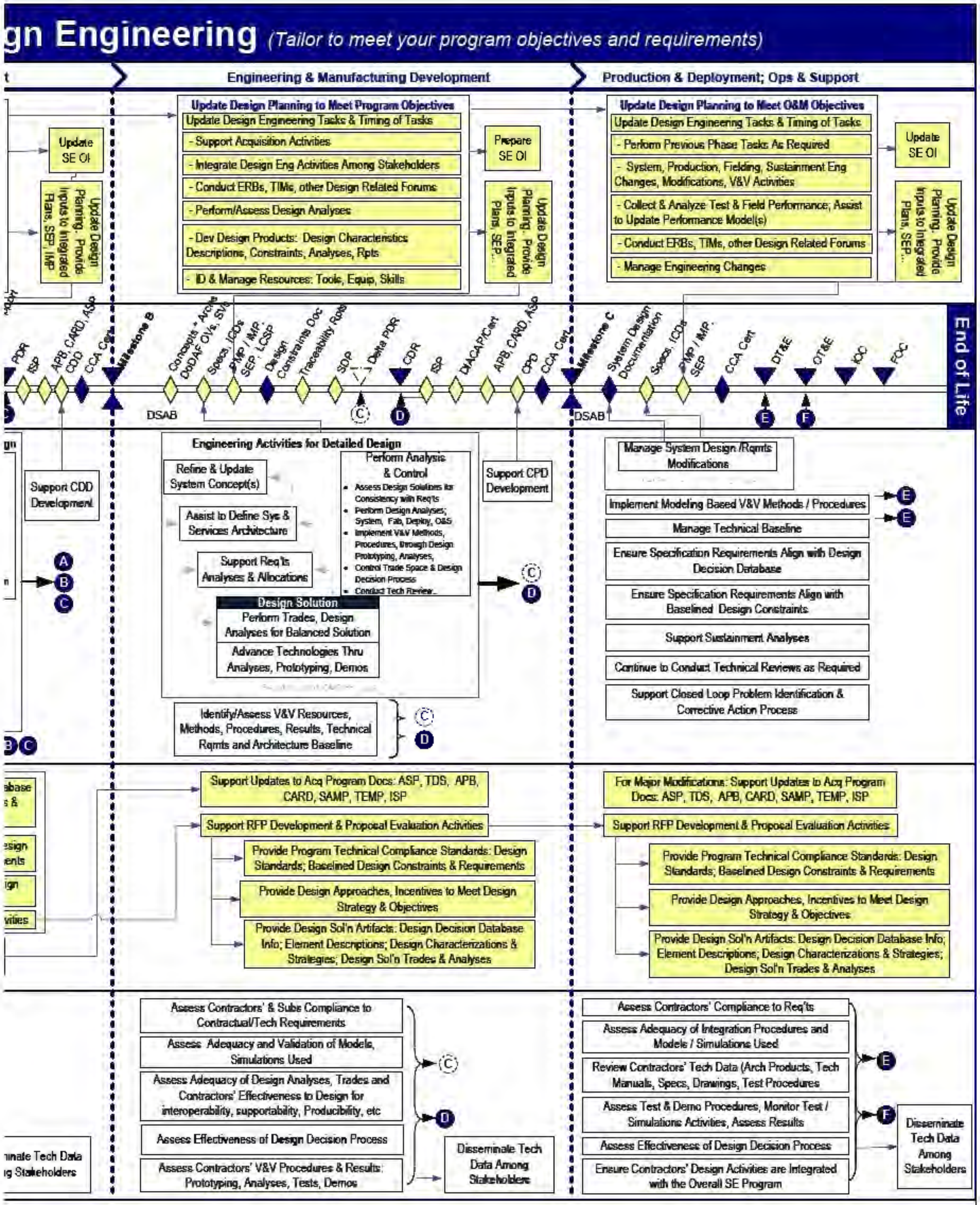


Figure 7 Acquisition life cycle process for SMC Design Engineering


gn Engineering (Tailor to meet your program objectives and requirements)
Engineering & Manufacturing Development
Production & Deployment; Ops & Support
Update Design Planning to Meet Program Objectives
Update Design Engineering Tasks & Timing of Tasks
- Support Acquisition Activities
- Integrate Design Eng Activities Among Stakeholders
- Conduct ERBs, TIMs, other Design Related Forums
- Perform/Assess Design Analyses
- Dev Design Products: Design Characteristics Descriptions, Constraints, Analyses, Rpts
- ID & Manage Resources: Tools, Equip, Skills
Update SE OI
Update Design Planning. Provide Inputs to Integrated Plans, SEP, IMP
Prepare SE OI
Update Design Planning. Provide Inputs to Integrated Plans, SEP...
Update Design Planning to Meet O&M Objectives
Update Design Engineering Tasks & Timing of Tasks
- Perform Previous Phase Tasks As Required
- System, Production, Fielding, Sustainment Eng Changes, Modifications, V&V Activities
- Collect & Analyze Test & Field Performance; Assist to Update Performance Model(s)
- Conduct ERBs, TIMs, other Design Related Forums
- Manage Engineering Changes
Update SE OI
Update Design Planning. Provide Inputs to Integrated Plans, SEP...
PDR
ISP
APB, CARD, ASP
CDD
CCA Cert
Milestone B
Concepts • Arch
DODAF OVs, SVs
Specs, ICDs
PMP / IMP, SEP, LCSP
Design Constraints Doc
Traceability Rpts
SDP
Delta PDR
CDR
ISP
DIACAP/Cert
APB, CARD, ASP
CPD
CCA Cert
Milestone C
System Design Documentation
Specs, ICDs
PMP / IMP, SEP
CCA Cert
DT&E
OT&E
IOC
FOC
End of Life
DSAB
DSAB
Engineering Activities for Detailed Design
Refine & Update System Concept(s)
Assist to Define Sys & Services Architecture
Support Req'ts Analyses & Allocations
Perform Analysis & Control
• Assess Design Solutions for Consistency with Req'ts
• Perform Design Analyses; System, Fab, Deploy, O&S
• Implement V&V Methods, Procedures, through Design Prototyping, Analyses,
• Control Trade Space & Design Decision Process
• Conduct Tech Review
Design Solution
Perform Trades, Design Analyses for Balanced Solution
Advance Technologies Thru Analyses, Prototyping, Demos
Support CDD Development
Support CPD Development
Identify/Assess V&V Resources, Methods, Procedures, Results, Technical Rqmts and Architecture Baseline
Manage System Design /Rqmts Modifications
Implement Modeling Based V&V Methods / Procedures
Manage Technical Baseline
Ensure Specification Requirements Align with Design Decision Database
Ensure Specification Requirements Align with Baselined Design Constraints
Support Sustainment Analyses
Continue to Conduct Technical Reviews as Required
Support Closed Loop Problem Identification & Corrective Action Process
Support Updates to Acq Program Docs: ASP, TDS, APB, CARD, SAMP, TEMP, ISP
Support RFP Development & Proposal Evaluation Activities
Provide Program Technical Compliance Standards: Design Standards; Baselined Design Constraints & Requirements
Provide Design Approaches, Incentives to Meet Design Strategy & Objectives
Provide Design Sol'n Artifacts: Design Decision Database Info; Element Descriptions; Design Characterizations & Strategies; Design Sol'n Trades & Analyses
For Major Modifications: Support Updates to Acq Program Docs: ASP, TDS, APB, CARD, SAMP, TEMP, ISP
Support RFP Development & Proposal Evaluation Activities
Provide Program Technical Compliance Standards: Design Standards; Baselined Design Constraints & Requirements
Provide Design Approaches, Incentives to Meet Design Strategy & Objectives
Provide Design Sol'n Artifacts: Design Decision Database Info; Element Descriptions; Design Characterizations & Strategies; Design Sol'n Trades & Analyses
Assess Contractors' & Subs Compliance to Contractual/Tech Requirements
Assess Adequacy and Validation of Models, Simulations Used
Assess Adequacy of Design Analyses, Trades and Contractors' Effectiveness to Design for interoperability, supportability, Producibility, etc
Assess Effectiveness of Design Decision Process
Assess Contractors' V&V Procedures & Results: Prototyping, Analyses, Tests, Demos
Disseminate Tech Data Among Stakeholders
Assess Contractors' Compliance to Req'ts
Assess Adequacy of Integration Procedures and Models / Simulations Used
Review Contractors' Tech Data (Arch Products, Tech Manuals, Specs, Drawings, Test Procedures
Assess Test & Demo Procedures, Monitor Test / Simulations Activities, Assess Results
Assess Effectiveness of Design Decision Process
Ensure Contractors' Design Activities are Integrated with the Overall SE Program
Disseminate Tech Data Among Stakeholders
A
B
C
D
E
F

4. **Production & Deployment, Operations & Support.** During the Production and Deployment phase, Design efforts are concentrated on the evaluation proposed engineering changes, assessments of production and fielding tests, and production and fielding challenges that potentially alter the baselined design. The Design Engineer provides inputs to and supports program acquisition activities to include updates to the acquisition strategy and updates to the cost model to reflect the actual technical solutions determined. The Design Engineer supports the solicitation/RFP development and proposal evaluation activities. The Design Engineer identifies other contract requirements: production and field test & demo requirements; field performance and sustainment analyses to meet program objectives. At the end of its useful life, the Design Engineer ensures that the system is demilitarized and disposed of in accordance with all legal and regulatory requirements and policy.

P&D / O&S Phase – SMC Acquisition Products
Updates to ASP, TDS, DMS
RFP: design objectives in the SOO; design related tasks in SOW; SMC- Design standards - tailored
Detailed planning, SEP, LCMP, TEMP updates
CARD update

Design Engineers' Contributions to Engineering Life Cycle Framework

Relationship to the SE Organization

The Design Engineer plans and executes the essential design engineering efforts in an integrated and effective manner within the context and full support of the overarching Systems Engineering function. The Design Engineer ensures that their SED contributions are timely, adequate, consistent, and compliant. The Design Engineer ensures that their contributions are channeled through the Systems Engineering *Analyses and Control* activity.

Systems Engineers manage the engineering process and activities depicted in Figure 3 while the Design Engineer contributes to this process. The Design Engineer may be designated to be the process owner of the *Design Solution* element of the process as well as select Analyses & Control activities. The set of activities associated with the design solution (synthesis) element is described in the SMC Systems Engineering Primer and Handbook.

In addition the Design Engineer defines and provides the roadmap to realize system design characteristics that provide producible, reliable and maintainable systems; modular open systems; diagnostics, prognostics, and health management in embedded and off-equipment applications; and system designs that minimize or eliminate system characteristics that require excessive cognitive, physical, or sensory skills; entail extensive training or workload-intensive tasks; result in mission-critical errors; or produce safety or health hazards. Table 9 below highlights typical design characteristics that are addressed in SMC space systems acquisition strategies, transformed into system requirements, and implemented through design practices.

Table 9 Typical Design Characteristics Addressed in SMC Space Systems Acquisition Strategies

Design Characteristic	Characteristic Descriptions	Source
Producible	Design analyses for manufacturing efficiencies	Manufacturing SED
Reliable	Design analyses and test to determine product life. Failure analyses to model system reliability and determine potential failure modes and remedy reliability issues	SMCI 63-1201 SMC RAM Instruction
Maintainable	Design analysis to determine ease of maintenance and remedy maintainability issues	SMCI 63-1201 SMC RAM Instruction
Modular Open Systems	Design for open systems. Incorporates the six basic elements of an open architecture into all design considerations and trades: open-standards, interoperable, interchangeable, portable, modular, and scalable. Design for desirable attributes of modular units such as low coupling, high cohesion, and low connectivity.	SMC Systems Engineering Primer and Handbook
Diagnostics, Prognostics, & Health Management	Design for autonomous or prompted space systems fault detection, isolation, and management	SMCI 63-1201 SMC RAM Instruction
Interoperable	Design for interoperability. Systematically derive the system functionality from the operationally stated interoperability constraints. Collaborate functional and physical interface architectures, requirements, and designs across systems, operators, maintainers	CJCSI 6212.01E Interoperability and Supportability of Information Technology & National Security Systems
Scalable & Expandable	Plan and design for growth to support future needs: physical expansion, increased capacity, improved performance. Define growth strategies, requirements, and design characteristics.	SMC Systems Engineering Primer and Handbook
Interchangeable	Design practice to select common parts, materials, processes, components; reuse software, documentation, and procedures.	SMC Systems Engineering Primer and Handbook

The Design Engineer supports concept and architecture development and analyses; modeling and simulation efforts; technology studies, and technology advancement efforts. The Design Engineer develops/derives design related requirements and supports the requirements analyses and allocations process. He/she also participates and sometimes manages the technical studies and technical solutions trades. The Design Engineer provides design analyses contributions to determine or assess design characteristics, propose alternative solutions, and determine mitigating actions or solutions to problems or identified risks through prototyping efforts. The Design Engineer also works closely with the Systems Engineers performing interface analyses and functional analyses. The Design Engineer also supports the integration and verification and validation planning and execution.

In performing the management and control function, the Systems Engineer effectively integrates all engineering functions through the full system life cycle. The Design Engineer ensures their technical contribution to the overall engineering advances and is applied through systematic control, collaboration and sharing across the organization. For example, their products, e.g., documented design constraints, are timed to coincide with architectural trades, design trades, reliability analyses (fault tree, failure modes, critical items lists, reliability block diagrams, etc). In addition, Design Engineering products are timed and applied by the other Specialty Engineers to perform their unique contributions, and must be provided to technical and program managers for decision making.

Relationship to other SEDs

The Design Engineer SED relationship to other SEDs is summarized in Figure 1. Design Engineer interactions with the other SEDs are critical to perform and integrate their engineering contributions to the system development efforts. Design Engineers team with the architecture engineers, Operations Analysts, and others to perform technology assessments and advance technologies. Design Engineers team with the requirements analysts and multiple specialty engineers to perform technical solutions trades, requirements analyses and baseline control of the design constraints.

The Design Engineer works closely with the Manufacturing Engineers, QA/QE, and Process Engineers to ensure the production environment is adequately designed and controlled to preserve the design during production, packaging, shipping, and handling.

Tools Selection and Use

The Design Engineer considers effectiveness and efficiencies gained by selecting and using the best choice of Design Engineering tools considering the tool requirements for identifying, analyzing, and managing the design requirements and design constraints; performing technology trades and advancing technologies through maturity.

Typical Design Engineering Functions Requiring Tools
Technology trades
Technology Readiness Assessments
Design constraints analyses

Engineering Activities and Products over the Life Cycle

Engineering activities that are unique to design engineering include:

- Maintain the integrity of the technical solutions decision process
- Manage or support an effective technology development program
- Identify and analyze design requirements and constraints
- Ensure the design baseline is appropriately defined and managed during development

Design Analyses. The Design Engineer promotes adherence to all applicable statutes and to contractually designated design requirements as applicable. The Design Engineer ensures the Contractor(s) identify and analyze all applicable design factors; employs design techniques to mitigate design related risks or challenges; avoids use of products and materials that present personnel and environmental hazards and minimizes life cycle costs burdens. Design analyses are performed in many forms to essentially ensure that the final design reconciles engineering problems and provides balanced solutions. Design-related tradeoffs and analyses are presented throughout the System Engineering process to identify balanced technical solutions.

Example SMC specifications and standards program for space vehicles include the following design categories:

- Structures
- Moving Mechanical Assemblies
- Pressurized Hardware
- Electrical Power
- Ordnance
- Parts, Materials, & Processes
- Software

Other design related analyses may include thermal, shock and vibration, safety, reliability, *critical program* information protection and design countermeasures, and other analyses. The following subsections delineate Design Engineer contributions to engineering activities and technical products by DoD acquisition phase. Refer to SMC-S-001 for a more complete list of Design Engineer activities and products prepared by the Program Office and their Contractors.

1. **Materiel Solution Analysis.** This is the initial study phase. Top level requirements, broad alternative solutions to the space mission, its components, interfaces and constraints are defined, along with technology development strategies, risk assessments and mitigation approaches are developed. During this phase the Design Engineer may provide inputs to and support the Capabilities Based Assessment process and the JCIDS process. The Design Engineer evaluates proposed concepts and architectures to identify and assess implications of conceptual solutions to unnecessarily constraining trade-space and provides recommendations for each alternative. The Design Engineer assists to define / refine design constraints and technology related requirements to support the 1st iteration of the requirements analysis of the Initial Capabilities Document (ICD). The Design Engineer also and contributes to the development of the MSA Phase technical products in support of Milestone A.

MSA Phase – Technical Products Required	
SMC Design Engineer Technical Products	**Contributions to Other Organizations' Products**
High level assessment proposed concepts & archs	Operational Concepts
Design inputs and factors for concept, architecture, technology studies, and trades	AoA Studies
Design constraints and design req'ts (draft)	ICD Dev

2. **Technology Development.** During this phase the Design Engineer continues reassessment and validation of requirements, development of designs for alternative mission concepts, perform architecture trades; develop brass boards and prototypes as necessary for risk mitigation to provide inputs to and supports the JCIDS process and Milestone B. The Design Engineer also supports all the engineering activities highlighted within the box titled Engineering Activities for System & Segment Development & Design Figure 7 to commence system definition and development. Design Engineer develops and contributes to development of the TD Phase technical products. The Design Engineer typically manages or ensures effective execution of the Design Solution element of the process. The Design Engineer also contributes to the development and updates to the TD Phase acquisition and engineering products. The Design Engineer may lead or support technology trades, technology advancement strategies, technology readiness assessments, critical technology assessments, and evaluations of alternative solutions. The Design Engineer begins to document technical solutions decisions (see section below Design Engineers' Contributions to Engineering Life Cycle Framework)

TD Phase – Technical Products Required	
SMC Design Engineer Technical Products	**Contributions to Other Organizations' Products**
Technology studies & assessments. Factors for other studies/ trades	Operational Concepts
Identification of Critical Technologies	Operational Assessments
Design constraints / reqts	CDD
Inputs to arch dev: physical elements & descriptions	DoDAF CVs, OVs , ISPs
Inputs to system design, production, fielding, sustain docs	System Baseline Documentation

3. **Engineering & Manufacturing Development.** Design engineer supports completion of detailed definition and design of system components, design/requirements compliance and verification, development of test hardware and software. Design Engineer continues to provide inputs to and supports the JCIDS process for Milestone C. The Design Engineer supports all the engineering activities highlighted within the box titled Engineering Activities for Detailed Design Figure 7 to commence detailed systems definition and development. The design Engineer documents the evolving design elements, aligns the elements to the specification tree, CARD architecture, and DoDAF architecture products. The design engineer ensures design related constraints and requirements are defined, analyzed, and managed through the requirements development and management process. The design engineer assesses the Contractor design analyses activities, results and ensures contract compliance. The Design Engineer ensures process is in place to report, analyze, and mitigate design issues during DT&E. The Design Engineer provides inputs to and supports the JCIDS process. Refer to SMC-G-001 for Design Engineer activities and products typically required during each phase. The Design Engineer develops and contributes to the development of the EMD Phase technical products.

EMD Phase – Technical Products Required	
SMC Design Engineer Technical Products	**Contributions to Other Organizations' Products**
Technology Studies, assessments. Factors for other studies/ trades	Operational Concepts
Identification of Critical Technologies	Operational Assessments
Documented design constraints / requirements	Capabilities Production Doc (CPD)
Inputs to architecture development:: physical elements and descriptions determined through trades & analyses	DoDAF CVs, OVs , ISP
Inputs to system design, production, fielding, sustain docs	System Baseline Documentation

4. **Production & Deployment, Operations & Support.** The Design Engineer continues to assess the design to determine if it meets the contractual requirements and that build and integration activities do not induce additional Design risks. The Design Engineer supports technical baseline engineering change activities. Construction of ground and flight systems, system integration and test, operations and maintenance of the system takes place in this phase. The design engineer provides operations and maintenance oversight and support through end of life. The Design Engineer ensures that the build instructions adequately implement the documented design and ensures the manufacturing environment mirrors the manufacturing design. (This is usually performed during the PCA.) The Design Engineer helps the Program Office address end-of-life safing, and space environments per AFSPC Supplement to AFI 91-202. The Design Engineer develops and contributes to the development of the Production & O&S Phase technical products.

P&D / O&S Phase – Technical Products Required	
SMC Design Engineer Technical Products	**Contributions to Other Organizations' Products**
Inputs tech baseline engineering changes	Supportability assessment Rpt Contribution
Analyses of failures and mishap incidents	Operational Assessments Contributions
	Transition & Fielding Docs
T&E / Demo Reports	
Evaluations of Tech Orders, operations manuals	

Design Engineers' Contributions to Program and Project Management

Each SMC program defines their business model and approach structure based primarily on their program objectives, program and technical challenges, organizational structure, as well as program and engineering planning (SEP plus detailed engineering planning).

The Design Engineer develops and implements a Design engineering approach to achieve Program Office Design engineering objectives and requirements. The approach, which is documented in the SEP, defines the Design Engineering tasks and functions to be performed and products to be developed; timing of tasks, task outputs, resources (skills, tools, equipment, and completion criteria). The Design Engineer plans tasks to integrate design activities within the Program Office, between Contractors and stakeholders. The Design Engineer plans the tasks to establish and manage the design solutions and decision process; technical review forums; support SE&I activities, risk management, integration, and system modifications; coordinate the engineering planning with SMC Staff Design Engineering office, integrate design engineering planning with other functional and acquisition plans (i.e., SEP, ASP/Acquisition Strategy Document, LCMP).

Execution of the Design Engineer planning is typically defined through an Operating Instruction which implements SMC and higher level instructions, policies, and directives. The Design Engineer provides full support to define the program and technical objectives where design challenges and risks are known or anticipated. The Design Engineer assists to establish the business model, develop program planning and schedules, and define and implement program processes. The Design Engineer ensures the technical solutions elements of the program are appropriately represented in the program plans, program schedules, work breakdown schedules, cost estimates. The Design Engineer also reports their technical performance and progress. The Design Engineer shares in the risk management responsibilities to identify, assess, and propose mitigating actions of design related risks. They also support the program manager's problem identification, resolution, and decision-making processes.

SMC Program Management Products
PMD
SEP, IMP, IMS, WBS
Decision-making & problem solving
Technical progression and issues reporting
LC Cost Estimate (CARD)
Processes (OIs)
Risk Management Inputs

The Design Engineer contributes to the development of the program management products identified in the Table.

Appendix E – Manufacturing and Producibility

The SMC Manufacturing & Producibiity Engineer, hereafter referred to as Manufacturing Engineer (ME), has the responsibility to formulate and execute the Manufacturing and Producibility Program for new and existing programs at SMC. The ME plans and executes the essential Manufacturing Engineering and Manufacturing Management for the contracted manufacturing operations to ensure that manufacturing planning and operations are timely, adequate, consistent, and compliant. The ME ensures that manufacturing engineering contributions are channeled through the Systems Engineering *Analyses and Control* activity.

Applicable governance, standards, and guidance

Policy, directives, and instructions that mandate manufacturing engineering and management requirements are included in a wide range of mandates including those for acquisition, T&E, software, systems engineering, and others. Governance specific to manufacturing and producibility extends from United States Code (USC) Title 10, Federal Acquisition Regulations, as well as DoD and Air Force directives and instructions. Mandated requirements that the ME must address also span the full acquisition lifecycle from the requirements to assess the critical technology elements (CTEs) associated with each proposed materiel solution, including manufacturing feasibility, and, where necessary, demonstration needs; Industrial Base assessments and protection; and continual assessments and actions to mitigate manufacturing sources. One of the most important tasks for the SME ME to accomplish is to tailor the application of the governance and standards to the particular system acquisition to assure that manufacturing and producibility are appropriately included in the RFP and eventual contract SOW, CDRL, and baseline of technical requirements.

National Technology and Industrial Base (10 U.S.C. 2506). The ME ensures technological and industrial capability considerations are integral to SMC space systems acquisitions practices to develop, produce, maintain, and support the industrial base protection program. The ME ensures performance of an analysis of the capabilities of the national technology and industrial base to develop, produce, maintain, and support such program, including consideration of the following factors related to foreign dependency:

1.) The availability of essential raw materials, special alloys, composite materials, components, tooling, and production test equipment for the sustained production of systems fully capable of meeting the performance objectives established for those systems; the uninterrupted maintenance and repair of such systems; and the sustained operation of such systems.
2.) The identification of items that are available only from sources outside the national technology and industrial base.
3.) The availability of alternatives for obtaining such items from within the national technology and industrial base if such items become unavailable from sources outside the national technology and industrial base; and an analysis of any military vulnerability that could result from the lack of reasonable alternatives.
4.) The effects on the national technology and industrial base that result from foreign acquisition of firms in the United States.

The ME also ensures the following considerations are integral to SMC space systems acquisitions practices

1.) Consideration of requirements for efficient manufacture during the design and production of the systems to be procured under the program.
2.) The use of advanced manufacturing technology, processes, and systems during the research and development phase and the production phase of the program.
3.) To the maximum extent practicable, the use of contract solicitations that encourage competing Offerors to acquire, for use in the performance of the contract, modern technology, production equipment, and production systems (including hardware and software) that increase the productivity of the Offerors and reduce life-cycle costs.
4.) Methods to encourage investment by U.S. domestic sources in advanced manufacturing technology production equipment and processes through –(I) Recognition of the contractor's investment in advanced manufacturing technology production equipment, processes, and organization of work systems that build on workers' skill and experience, and work force skill development in the development of contract objective; and(ii) Increased emphasis in source selection on production efficiency.
5.) Expanded use of commercial manufacturing processes rather than processes specified by DoD.
6.) Elimination of barriers to, and facilitation of, the integrated manufacture of commercial items and items being procured under DoD contracts.
7.) Expanded use of commercial items, commercial items with modifications, or to the extent commercial items are not available, non-developmental items
8.) Acquisition of major weapon systems as commercial items.

The ME also ensures implementation of best manufacturing practices and consistent proven processes through standardization. Although Mil-Std-1528A has been canceled, it is a required compliance standard for SMC major acquisitions. This standard contains excellent information on the objectives and specific activities/outputs for Manufacturing Management and Manufacturing Engineering and is tailored for use on each developmental and production acquisition. Table 10 below identifies the most significant governance, standards, and guidance which generally apply to SMC for manufacturing and producibility.

Table 10 Governance, standards, and guidance that shape the Manufacturing Engineering discipline.

Document No	Governance Title	Issue
10 U.S.C. 2505, 2506	National Technology and Industrial Base	
DFARS 207.105(b)(20)(A)	National Technology and Industrial Base	
DFARS Subpart 234.70	Acquisition of major weapon systems as commercial items	
DoD Directive 4245.6	Defense Production Management	19 Jan 84
DoDI 4200.15	Manufacturing Technology Program	19 Sep 02
DoDI 5000.02	Operation of the Defense Acquisition System	08 Dec 08
DoD 4245.7-M	Transition from Development to Production	Sep 85
Document No	**Standards Title**	**Issue**
Mil-Std-1528A	Manufacturing Management Program	09 Sept 86
Mil-Std-1540D	Product Verification Reqts for Launch, Upper Stage, and Space Vehicles	15 Jan 99
SMC-S-009	PMP Control Program for Space and Launch Vehicles	12 Jan 09
SMC-S-010	Technical Requirements for Electronic Parts, Materials, and Processes for Space and Launch Vehicles	12 Jan 09
SMC-S-011	PMP Control Program for Expendable Launch Vehicles	13 Jun 08

Document No	Guidance Title	Issue
SMC CPATS	Manufacturing	19 Sep 06
DFARS PGI 207	Acquisition Planning	
Mil-Hdbk-727	Design Guidance For Producibility	5 Apr 84
Mil-Hdbk-896	Manufacturing and Quality Program	8 Aug 08
www.bmpcoe.org	Best Manufacturing Practices	

ME Contributions to the Acquisition Life Cycle Framework

The DoD acquisition life cycle is defined by DoDI 5000.02. ME contributions over this life cycle are initiated during the acquisition phase. The ME supports pre and post contract award activities, by stipulating manufacturing requirements and performing manufacturing management and engineering analyses across the system lifecycle. SMC Program Offices establish and implement manufacturing and producibility program strategies and objectives consistent with appropriate policies, SMC objectives, and program objectives. The Program Office then develops manufacturing plans obtains approval for them, and incorporates manufacturing planning into the Systems Engineering Plan (SEP) and higher level integrated planning (e.g., IMP) in accordance with current DoD policy. This planning is firmly based on program and technical objectives, strategies, DoD mandates, and instructions.

An effective manufacturing and producibility program supports all of the major acquisition activities through the full system life cycle. The Systems Engineering process assures that the manufacturing function is considered early in the concept phase when producibility considerations are paramount in conducting trade studies of the preliminary and evolving concepts. As system functions are defined and solutions are synthesized in the design evolution, each proposed solution is evaluated to identify any producibility concerns and provide manufacturing alternatives that may impact the design to insure consistent repeatability in the hardware manufacturing process.

DoD envisions a prevention-based strategy that encourages continuous improvement across the industry by identifying the most advanced methods of manufacturing that could be applied to the program. The ME assists the Program Office to identify those contractors that provide evidence of using recognized advanced manufacturing concepts (design for manufacturing, reduced variation and process control techniques, improved value streams, defect free products) so that they can be given proper credit during the source selection process (reference GAO/NSIAD-96-162 Best Practices).

Manufacturing and producibility planning should define a program that achieves the overall program objectives and requirements; specifies tasks and functions to be performed, timing of tasks, resources required, products to be developed, that forms the basis for the development of the Manufacturing and Producibility Operating Instruction (OI). The manufacturing planning and OI are then reflected appropriately in the WBS, IMS, and other program documents that address manufacturing and producibility related elements. The manufacturing planning is executed concurrently with the Program Office OI that documents the process to perform, control, and integrate all manufacturing engineering and management activities for each phase of acquisition. The SMC Program Office manufacturing planning is documented in the SEP and, the detailed manufacturing program plans; then the OI are based upon these documents. SMC Program Offices appoint ME personnel, establish and implement manufacturing and producibility program strategies and objectives consistent with appropriate policies, SMC acquisition objectives, and program objectives.

1. **Materiel Solution Analysis.** During this phase the ME provides inputs to and supports most program acquisition activities to include the development of the acquisition strategy, inputs to the cost estimates, requirements for solicitation/RFP development for Contractor studies, and proposal evaluation criteria. The ME also contributes to the development of the MSA Phase acquisition products that are impacted by or impact manufacturing and producibility.

MSA Phase – SMC Acquisition Products
PMD
ASP, TDS, DMS, TES
LC Cost Estimate
RFP inputs:(manufacturing requirements; Manufacturing/producibility assessment requirements)
APB, CCA
SSP, SEP, LCMP

2. **Technology Development.** The ME identifies manufacturing technology acquisition activities that may be needed to produce the software and/or equipment for the new system. These efforts may include development of an acquisition strategy, updates to cost models and development of Cost Analysis Requirements Descriptions (CARD), solicitation/RFP requirements and proposal evaluation criteria. The ME identifies other contract requirements such as incentives/warranty programs, and design for manufacturing requirements to meet program objectives. The ME also contributes to the development and updates to the TD Phase acquisition products.

TD Phase – SMC Acquisition Products
Updates to ASP, TDS, DMS
LC Cost Estimate Update / CARD Development
RFP: Manufacturing requirements in the SOO; Mfg related tasks in SOW, Mfg data products in CDRLs; SMC- parts, materials, processes standards - tailored
SSP: evaluation criteria for manufacturing/producibility
APB: Mfg objectives & related concept descriptions
Detailed Mfg planning, SEP, LCMP, TEMP

3. **Engineering & Manufacturing Development.** The ME evaluates and approves supplier manufacturing plans and schedules so that they meet overall program timing requirements. The ME's effort includes updates to the acquisition strategy and updates to the cost model to reflect the actual technical solutions determined and updates to the CARD. The ME supports the solicitation/RFP development and proposal evaluation activities which include providing the technical inputs including technical manufacturing requirements, manufacturing compliance standards, manufacturing engineering and process control approaches, incentives, and warranty programs to meet program objectives. The ME also develops updates to the EMD Phase acquisition products related to manufacturing and producibility.

EMD Phase – SMC Acquisition Products
Updates to ASP, TDS, DMS
CARD update
RFP: Mfg requirements in the SOO; Mfg related tasks in SOW, Mfg data products in CDRLs; SMC- parts, materials, processes standards - tailored
SSP: Evaluation criteria for mfg/producibility
APB: Mfg requirements & related concept descriptions
Detailed Mfg planning, SEP, LCMP, TEMP updates

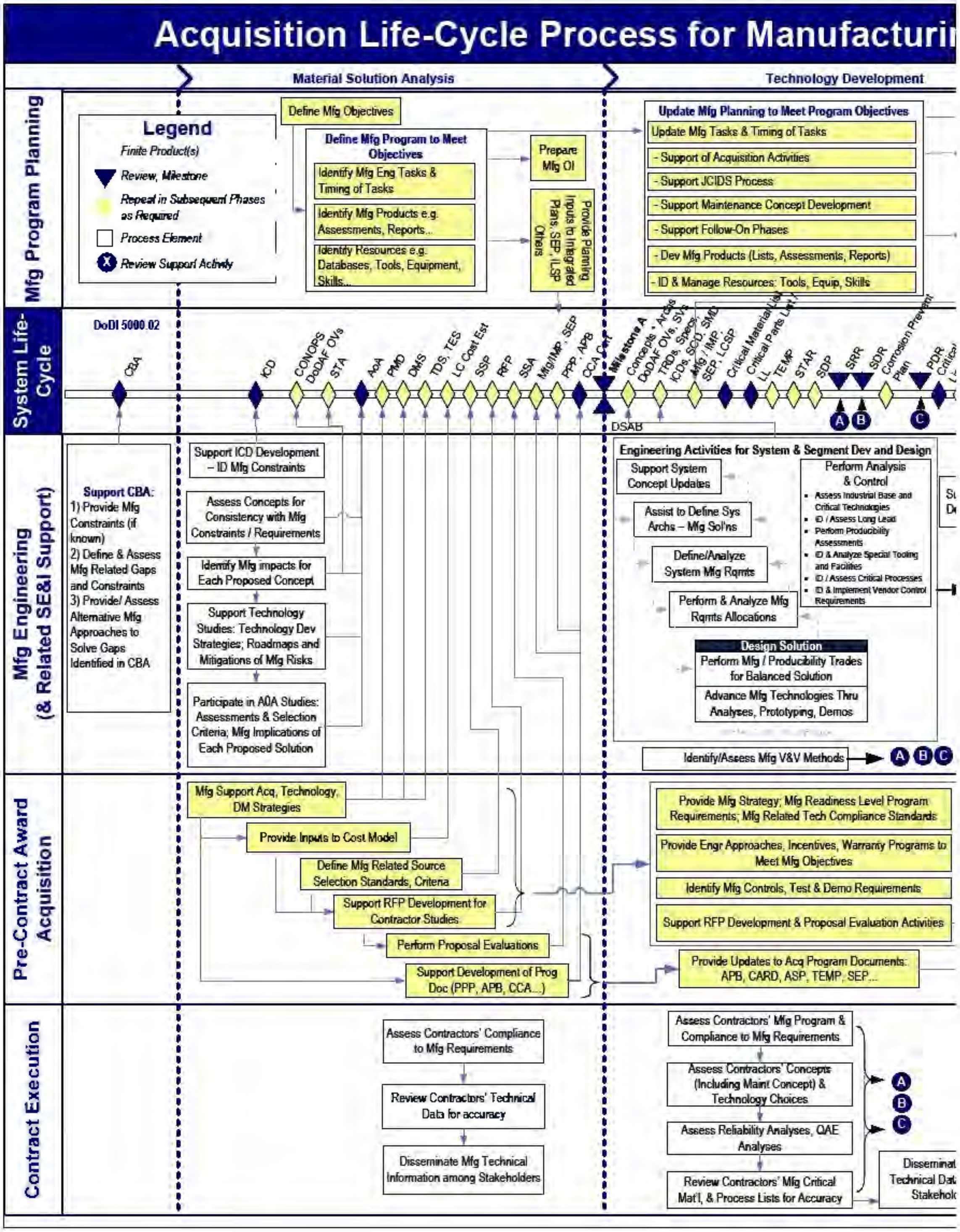
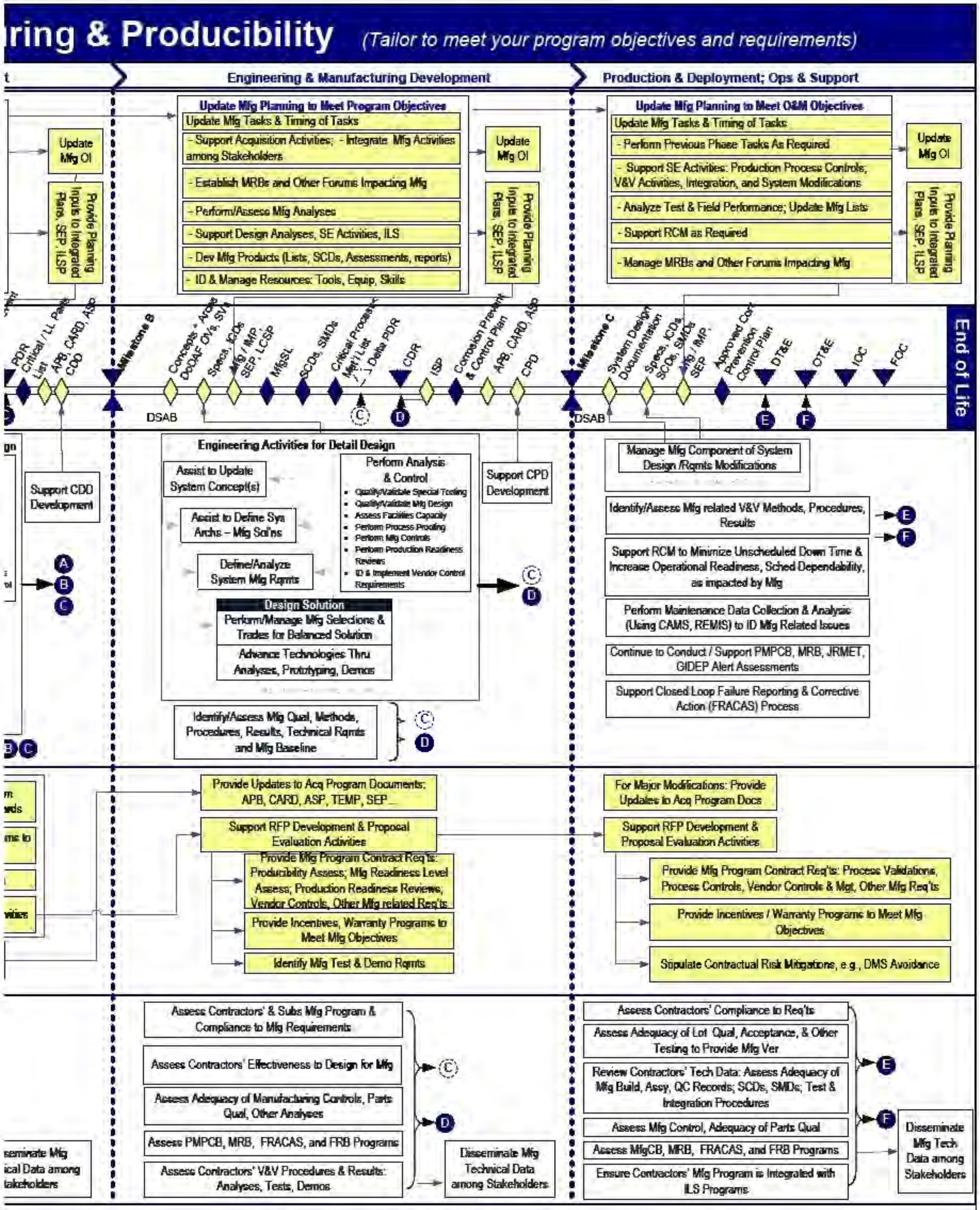


Figure 8 Acquisition life cycle process for SMC Manufacturing and Producibility



ring & Producibility (Tailor to meet your program objectives and requirements)
Engineering & Manufacturing Development
Production & Deployment; Ops & Support
Update Mfg Planning to Meet Program Objectives
Update Mfg Tasks & Timing of Tasks
- Support Acquisition Activities; - Integrate Mfg Activities among Stakeholders
- Establish MRBs and Other Forums Impacting Mfg
- Perform/Assess Mfg Analyses
- Support Design Analyses, SE Activities, ILS
- Dev Mfg Products (Lists, SCDs, Assessments, reports)
- ID & Manage Resources: Tools, Equip, Skills
Update Mfg OI
Provide Planning Inputs to Integrated Plans, SEP, ILSP
Update Mfg Planning to Meet O&M Objectives
Update Mfg Tasks & Timing of Tasks
- Perform Previous Phase Tasks As Required
- Support SE Activities: Production Process Controls; V&V Activities, Integration, and System Modifications
- Analyze Test & Field Performance; Update Mfg Lists
- Support RCM as Required
- Manage MRBs and Other Forums Impacting Mfg
End of Life
Milestone B
Milestone C
CDR
ISP
CPD
DT&E
OT&E
IOC
FOC
DSAB
Engineering Activities for Detail Design
Assist to Update System Concept(s)
Assist to Define Sys Archs – Mfg Sol'ns
Define/Analyze System Mfg Rqmts
Perform Analysis & Control
Design Solution
Perform/Manage Mfg Selections & Trades for Balanced Solution
Advance Technologies Thru Analyses, Prototyping, Demos
Support CDD Development
Support CPD Development
Identify/Assess Mfg Qual, Methods, Procedures, Results, Technical Rqmts and Mfg Baseline
Manage Mfg Component of System Design /Rqmts Modifications
Identify/Assess Mfg related V&V Methods, Procedures, Results
Support RCM to Minimize Unscheduled Down Time & Increase Operational Readiness, Sched Dependability, as impacted by Mfg
Perform Maintenance Data Collection & Analysis (Using CAMS, REMIS) to ID Mfg Related Issues
Continue to Conduct / Support PMPCB, MRB, JRMET, GIDEP Alert Assessments
Support Closed Loop Failure Reporting & Corrective Action (FRACAS) Process
Provide Updates to Acq Program Documents: APB, CARD, ASP, TEMP, SEP ...
Support RFP Development & Proposal Evaluation Activities
Provide Mfg Program Contract Req'ts: Producibility Assess; Mfg Readiness Level Assess; Production Readiness Reviews; Vendor Controls, Other Mfg related Req'ts
Provide Incentives, Warranty Programs to Meet Mfg Objectives
Identify Mfg Test & Demo Rqmts
For Major Modifications: Provide Updates to Acq Program Docs
Support RFP Development & Proposal Evaluation Activities
Provide Mfg Program Contract Req'ts: Process Validations, Process Controls, Vendor Controls & Mgt, Other Mfg Req'ts
Provide Incentives / Warranty Programs to Meet Mfg Objectives
Stipulate Contractual Risk Mitigations, e.g., DMS Avoidance
Assess Contractors' & Subs Mfg Program & Compliance to Mfg Requirements
Assess Contractors' Effectiveness to Design for Mfg
Assess Adequacy of Manufacturing Controls, Parts Qual, Other Analyses
Assess PMPCB, MRB, FRACAS, and FRB Programs
Assess Contractors' V&V Procedures & Results: Analyses, Tests, Demos
Disseminate Mfg Technical Data among Stakeholders
Assess Contractors' Compliance to Req'ts
Assess Adequacy of Lot Qual, Acceptance, & Other Testing to Provide Mfg Ver
Review Contractors' Tech Data: Assess Adequacy of Mfg Build, Assy, QC Records; SCDs, SMDs; Test & Integration Procedures
Assess Mfg Control, Adequacy of Parts Qual
Assess MfgCB, MRB, FRACAS, and FRB Programs
Ensure Contractors' Mfg Program is Integrated with ILS Programs
Disseminate Mfg Tech Data among Stakeholders

P&D / O&S Phase – SMC Acquisition Products
Updates to ASP, TDS, DMS
RFP: Mfg requirements in the SOO; Mfg related tasks in SOW, Mfg data products in CDRLs; SMC- Parts, materials and processes standards - tailored
SSP: evaluation criteria for Mfg/producibility
Detailed Mfg planning, SEP, LCMP, TEMP updates
CARD update

4. Production & Deployment, Operations & Support. During this phase the ME monitors the performance of the suppliers in providing the system software and equipment. The ME provides inputs to and supports acquisition activities that are related to manufacturing including updates to the acquisition strategy, the cost model and the CARD; to reflect the actual technical solutions. The ME supports any solicitation/RFP development and proposal evaluation activities that may be required. The ME identifies other contract requirements such as value stream and process cycle efficiency analysis, production process capability analysis (in conjunction with the Quality Engineer), critical manufacturing steps and tests to verify product design conformance, incentives/warranty programs.

ME Contributions to the Engineering Life Cycle Framework

Relationship to the SE Organization

The ME plans and executes essential manufacturing engineering and management efforts within the context and full support of the overarching Systems Engineering function. The ME ensures that each Manufacturing and Producibility SED contribution is timely, adequate, consistent, and compliant, and that their contributions are channeled through the Systems Engineering *Analyses and Control* activity. Systems Engineers manage the engineering process and activities depicted in Figure 3 and the ME contributes to this process. The ME develops/derives the program specific manufacturing/producibility requirements and supports the requirements analyses and allocations process. They also participate in technical studies and solutions trades when manufacturing methods are a factor and/or schedules may be impacted. They provide design analyses contributions to determine the appropriate level of manufacturing surveillance through analyses, demo, inspection, and test.

The ME also works closely with the System Engineers performing interface analyses, functional analyses, and the integration and verification and validation planning and execution. The ME works closely with the Quality Assurance Officer/Engineer (QAOE) and Reliability and Maintainability (RAM) Engineer to ensure quality and reliability through controlled and predictable quality levels during production, handling, storage, packaging, and transportation.

In support of the overall program management and control function, the ME monitors and integrates all manufacturing engineering functions through the full system life cycle. The ME ensures that effective informational and process control techniques and advances are applied for systematic M&P control, collaboration and sharing across the organization. For example, some key lean manufacturing process control indicators are Process Cycle Efficiency = Value Added Time/Total Lead Time; and Process Capability (Cpk) = Process spread/specification tolerance and comparison to target value. The ME ensures their technical contribution to the overall systems engineering is appropriately applied through systematic control, collaboration and sharing across the organization. Since a do-it-right-the-first-time mindset must be realized by all acquisition specialists, the ME works closely with other specialty engineers in defining and accomplishing the product quality expectations. As any program evolves there are inevitable refinements and changes that can impact the manufacturing process. The ME must be able to react to program changes to assure that schedule and cost impacts are minimized. In addition, the ME products and metrics are timed and applied by the other Specialty Engineers to perform their unique contributions, and must be provided to technical and program management for decision making.

In addition, the ME works closely with the Quality Engineer and RAM Engineer to identify, assess and address process and workmanship concerns that may potentially impact product quality and reliability, and to review process improvement opportunities.

Tools Selection and Use

The ME considers effectiveness and efficiencies gained by selecting and using the best choice of manufacturing tools for manufacturing/ producibility system analyses, T&E, information sharing, automated data exchanges with other tools, and other considerations.

Typical Mfg Functions Requiring Tools
Process Capability (Cpk)
Mfg Requirements Analyses & Allocations + Metrics
Process Cycle Efficiency
Value/Value Stream Analysis
Theory of Constraints Analysis

Engineering Activities and Products over the Life Cycle

The following subsections delineate ME contributions to engineering activities and technical products by DoD acquisition phase. Refer to Mil-Std-1528A and the SMC CPAT for Manufacturing for a more complete description of manufacturing activities that are performed by the Program Office and their contractors.

1. **Materiel Solution Analysis.** During this phase, the ME may provide inputs to and support the Capabilities Based Assessment process and the JCIDS process. The ME also contributes to the development of the MSA Phase technical products.

MSA Phase – Technical Products Required	
SMC ME Technical Products	**Mfg Contributions to Other Organization's Products**
High level Mfg/Producibility requirements analysis	Operational Concepts
ME inputs for concept, arch, technology studies and trades	AoA Studies
Mfg System Req'ts (draft)	Initial Capabilities Doc (ICD) Dev
Roadmap inputs – mitigations of critical process points/ risks	DoDAF CVs, OVs

2. **Technology Development.** During this phase the ME continues to provide inputs to and supports the JCIDS process. The ME also supports all the engineering activities highlighted within the box titled *Engineering Activities for System & Segment Development & Design* Figure 8 to commence system definition and development. The ME contributes to development of the TD Phase technical products.

TD Phase – Technical Products Required	
SMC ME Technical Products	**Mfg Contributions to Other Organization's Products**
Inputs to System Concepts	Operational Concepts
Factors for Mfg applications	Operational Assessments
MfgTech Req'ts, TRD, SRD, Specifications, ICDs, Standards Selection/ Tailor	Capabilities Development Doc (CDD) PDRs, CDRs
Mfg inputs to ISP	DoDAF CVs, OVs
Mfg/Producibility Program Analysis Reports	Mfg Management Reviews

3. **Engineering & Manufacturing Development.** The ME continues to provide inputs to and support the JCIDS process. The ME supports all the engineering activities highlighted within the box titled *Engineering Activities for Detailed Design* Figure 8 to commence detailed systems definition and development. The ME establishes a manufacturing management reporting system across contractor's. The activities of the ME during this phase are important to assure the contractor is building things right the first time per design requirements and with minimal waste. Refer to Mil-Std 1528A and SMC Manufacturing CPAT for manufacturing program requirements and activities. The ME develops and contributes to the development of the EMD Phase technical products to assure a high level of manufactured-in quality.

EMD Phase – Technical Products Required	
SMC ME Technical Products	**Mfg Contributions to Other Organization's Products**
Update System Concept	Operational Concepts
Validate preferred mfg applications	Operational Assessments
Mfg System Tech Req'ts, TRD, SRD, Spec, ICDs	Capabilities Production Doc (CPD)
Inputs to system, production, fielding, sustain design docs	Manufacturing Readiness Reviews (MRRs), Test Readiness Reviews (TRRs
Mfg inputs to ISP	DoDAF CVs, OVs
Mfg/Producibility Program Analysis Reports	Management Reviews
Process Capability/Efficiency	Contractor assessments

4. **Production & Deployment, Operations & Support.** The ME continues to provide inputs to and supports the JCIDS process. The activities of manufacturing during this phase are extensive. Refer to Mil-Std-1528A and SMC Manufacturing CPATS for ME activities and products typically performed during each phase. The ME develops and contributes to the development of the P&D / O&S Phase technical products.

P&D / O&S Phase – Technical Products Required	
SMC ME Technical Products	**Mfg Contributions to Other Organization's Products**
Inputs to tech baseline/ engineering changes	Supportability Analyses Rpt
Analyses of contractor mfg reports and test reports	Operational Assessments Hardware Acceptance Reviews (HARs)
Transition & Fielding Docs	Logistics Reports
Mfg Analyses Reports	Management System Reviews
Process capability and cycle efficiency reports	Program Performance Reviews

ME Contributions to Program and Project Management

Each SMC program defines their business model and approach structure based primarily on their program objectives, program and technical challenges, organizational structure, as well as program and engineering planning. The ME develops and implements the manufacturing and producibility program planning to support program objectives and requirements. The planning defines the manufacturing engineering tasks and functions to be performed and products to be developed; timing of tasks, task outputs, resources (skills, tools, equipment), and completion criteria. The ME plans tasks to integrate contractor manufacturing activities within the program office, between Contractors and stakeholders. The ME plans the tasks to establish and manage the Manufacturing and Producibility program; support SE&I activities, e.g., production process controls, V&V activities, risk management, integration, system modifications, contractor manufacturing performance requirements; coordinate the manufacturing planning with the SMC Manufacturing and Producibility OPR, operating commands, supporting commands, and test agencies; and integrate manufacturing planning with other functional and acquisition plans (i.e. SEP, ASP, LCMP).

Execution of the manufacturing planning is typically defined through an Operating Instruction (OI). The ME helps define the program and technical objectives by identifying where manufacturing management and engineering should be applied. The ME assists to establish the business model, develop program planning and schedules, and to define and implement program processes. The ME ensures the manufacturing and producibility components of the program are appropriately represented in the program plans, program schedules, work breakdown schedules, and cost estimates. The ME also evaluates and reports the assigned program contractor's technical performance and progress. They support the program manager's problem identification, resolution, and decision-making processes.

SMC Program Management Products
PMD
SEP, IMP, IMS, WBS
Decision-making & problem solving inputs
Technical progression and issues reporting
LC Cost Estimate (CARDs)
Processes (OIs)
Risk Management Inputs

The ME provides inputs to the development of the program management products identified in the Table.

Appendix F – Quality Assurance

The SMC Quality Assurance Executive (QAE) has the responsibility to update and execute the Quality Assurance Program. The QAE plans and executes the essential Quality Assurance, Quality Engineering, and management efforts in an integrated and effective manner to ensure that each QA Specialty Engineering Discipline contribution is timely, complete, consistent, and compliant. The QAE ensures that their contributions are channeled through the Systems Engineering *Analyses and Control* activity.

Applicable governance, standards, and guidance

Policy, directives, and instructions that mandate quality assurance related program requirements are included in a wide range of mandates including those providing requirements for acquisition, T&E, software, Systems Engineering, and others. *All SMC acquisitions require a quality program!* Table 11 below identifies the most significant governance, standards, and guidance which generally require SMC compliance for Quality Assurance

Table 11 Governance, standards, and guidance that shape the Quality Assurance Engineering discipline.

Document No	Governance Title	Issue
DoDI 5000.02	Operation of the Defense Acquisition System	08 Dec 08
DoDI 4715.15	Environmental Quality Systems	11 Dec 06
AFI 63-501	Air Force Acquisition Quality Program & Supplement 1	31 May 94 1 May 98
AFI 63-1201	Life Cycle Systems Engineering	23 July 07
Document No	**Standards Title**	**Issue**
SAE-AS 9100, Rev B	Quality Systems-Aerospace Model for QA Design, Development, Production, Installation, and Service	06 Jan 04
ISO 9001:2008	Quality Management System-Requirements	13 Nov 08
AS 9100:2009	Quality Management Standard for Aviation, Space, and Defense Industries	15 Jan 09
SMC-S-003	Quality Assurance for Space and Launch Vehicles	13 Jun 08
Document No	**Guidance Title**	**Issue**
GAO/NSIAD-96-162	Best Practice Commercial Quality Assurance Practices Offer Improvements for DOD	August 96
Mil-Hdbk-896	Manufacturing and Quality Program	8 Aug 08
Defense Acquisition Guidebook (DAG)	DAG, Chapter 11: Program Management Activities, Section 11.3.3 Quality Management	Current at https://dag.dau.mil/
SMC CPATS	Critical Process Assessment Tool – Quality Assurance	6 January 97

The QAE implements the relevant requirements inherent in the above directives to facilitate the integration of quality considerations into the engineering, acquisition, and management processes. As part of risk reduction, the QAE supports the PM to identify, eliminate, and manage deficiencies; the QAE provides support to manage risks where potential deficiencies cannot be totally eliminated.

QAE Contributions to the Acquisition Life Cycle Framework

The DoD acquisition life cycle is defined by DoDI 5000.02. QAE contributions over this life cycle are first instituted during the acquisition phase. QAE supports pre and post contract award acquisition activities, and performs QA management and engineering across the system lifecycle. SMC Program Offices establish and implement QA program strategies and objectives consistent with appropriate government policies, SMC acquisition objectives, and program objectives. Using this guidance the Program Office develops, obtains approval for, and implements QA planning into the Systems Engineering Plan (SEP) and higher level integrated planning (e.g., IMP) in accordance with current DoD policy. Thus this planning is firmly based on program and technical objectives, strategies, DoD mandates, and instructions.

An effective QA program supports all of the major acquisition activities through the full system life cycle. DoD envisions a prevention-based quality strategy that encourages continuous improvement across the industry by identifying the most advanced methods of ensuring quality. Those contractors that provide evidence of using recognized advanced QA concepts (design for manufacturing, process control techniques, sound relationships with key suppliers, etc.) should be given credit during a source selection process (reference GAO/NSIAD-96-162 Best Practices).

QA program planning to achieve vigorous quality assurance and overall program objectives and requirements: specifies tasks and functions to be performed, timing of tasks, resources required, products to be developed and forms the basis for the development of the program Quality Assurance Operating Instruction (OI). The QA plan and OI are then reflected appropriately in the WBS, IMS, and other program documents that address QA related elements. The QA plan is executed concurrently with the Program Office OI that documents the process to perform, control, and integrate all quality assurance and management activities for each phase of acquisition. The SMC Program Office QA planning (usually contained in the SEP and the detailed QA program plan) and OI are to be based upon the appropriate program-plan. SMC Program Offices appoints QAE personnel; establishes and implements QA program strategies and objectives consistent with appropriate policies, SMC acquisition objectives, and program objectives.

MSA Phase – SMC Acquisition Products
PMD
ASP, TDS, DMS, TES
LC Cost Estimate
RFP inputs: (QA mission/operational/system requirements; QA Assessment requirements)
APB, CCA
SSP
QAP, SEP, LCMP

1. **Materiel Solution Analysis.** During this phase the QAE provides inputs to and supports most program acquisition activities including the development of the acquisition strategy, inputs to the cost estimates, solicitation/RFP development for Contractor studies, and proposal evaluation activities. The QAE also contributes to the development of the MSA Phase acquisition products by specifying applicable QA regulations and data items such as the QA Plan, QA inputs for the RFP development, QA prevention system and assessment requirements, and deficiency feedback system requirements. The QAE contributes to Contractor studies, evaluates alternative concept solutions, and identifies deficiencies and risks associated with each concept solution and proposal evaluation activities.

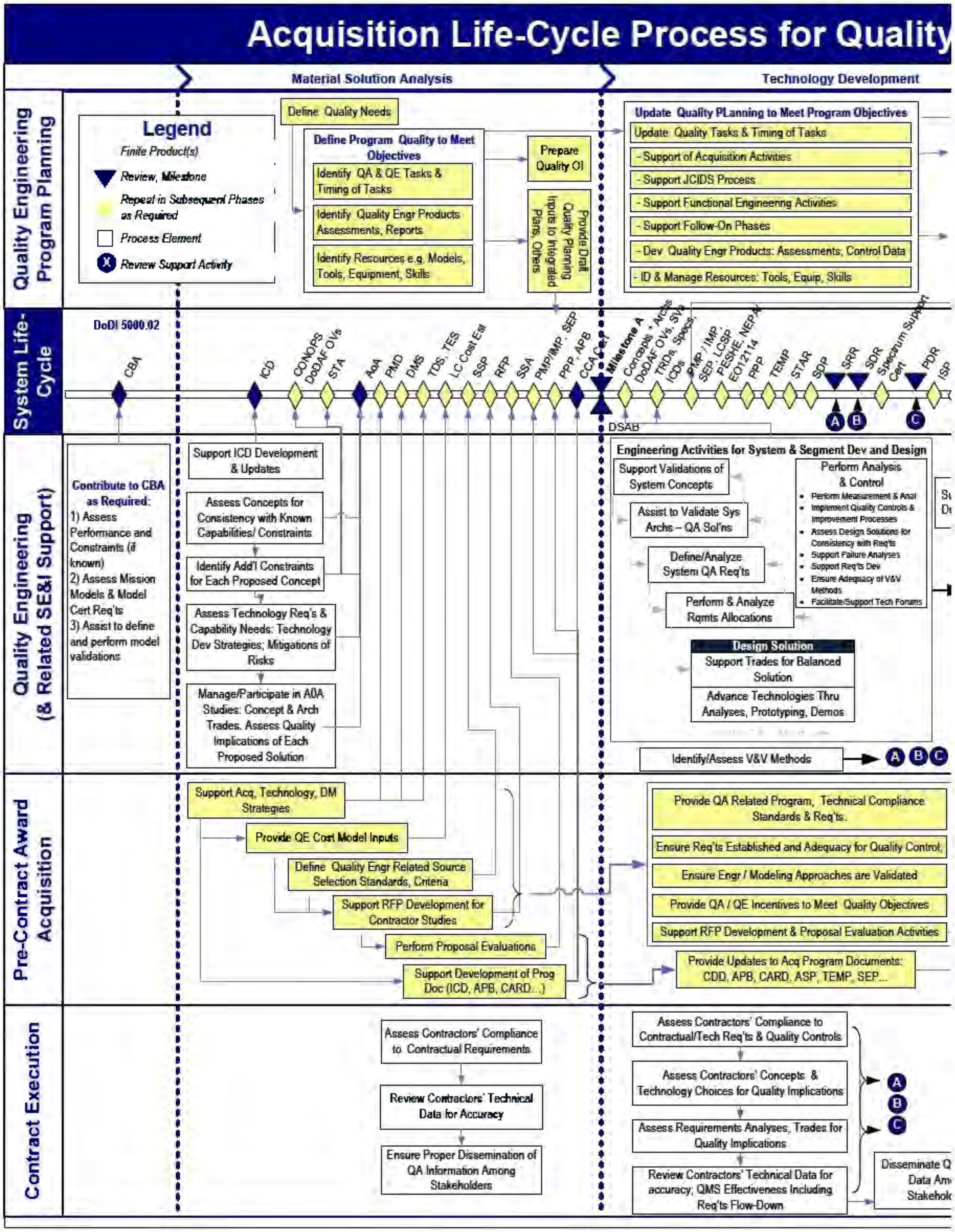
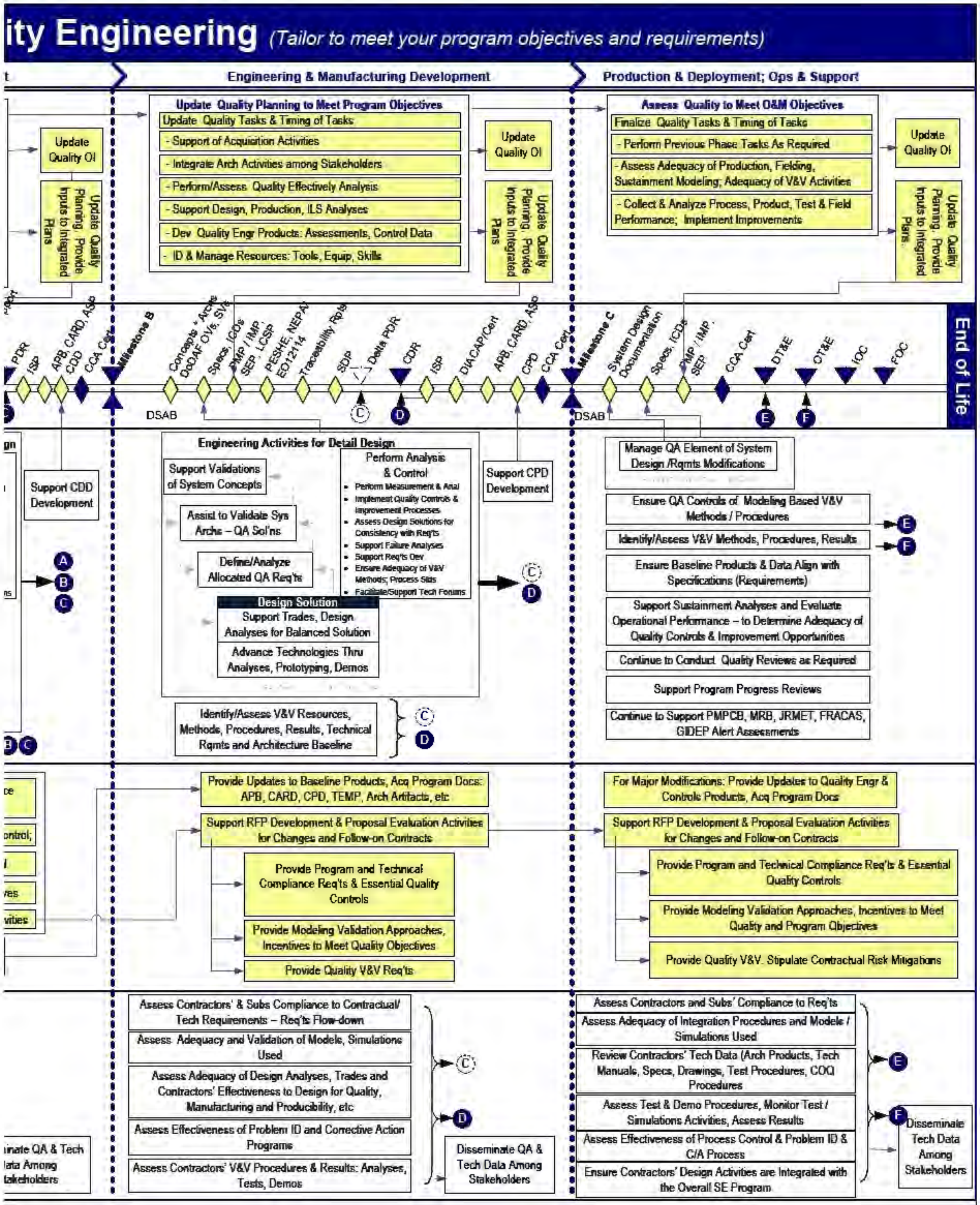


Figure 9 Acquisition life cycle process for SMC Quality Assurance Engineering


ity Engineering (Tailor to meet your program objectives and requirements)
Engineering & Manufacturing Development
Production & Deployment; Ops & Support
Update Quality OI
Update Quality Planning, Provide Inputs to Integrated Plans
Update Quality Planning to Meet Program Objectives
Update Quality Tasks & Timing of Tasks
- Support of Acquisition Activities
- Integrate Arch Activities among Stakeholders
- Perform/Assess Quality Effectively Analysis
- Support Design, Production, ILS Analyses
- Dev Quality Engr Products: Assessments, Control Data
- ID & Manage Resources: Tools, Equip, Skills
Assess Quality to Meet O&M Objectives
Finalize Quality Tasks & Timing of Tasks
- Perform Previous Phase Tasks As Required
- Assess Adequacy of Production, Fielding, Sustainment Modeling; Adequacy of V&V Activities
- Collect & Analyze Process, Product, Test & Field Performance; Implement Improvements
End of Life
PDR
ISP
APB, CARD, ASP
CDD
CCA Cert
Milestone B
Concepts + Archs DoDAF OVs, SVs
Specs, ICDs
PMP / IMP, SEP, LCSP
PESHE, NEPA EO12114
Traceability Rpts
SDP
Delta PDR
CDR
ISP
DIACAP/Cert
APB, CARD, ASP
CPD
CCA Cert
Milestone C
System Design Documentation
Specs, ICDs
PMP / IMP, SEP
CCA Cert
DT&E
OT&E
IOC
FOC
DSAB
DSAB
Support CDD Development
Engineering Activities for Detail Design
Support Validations of System Concepts
Assist to Validate Sys Archs – QA Sol'ns
Define/Analyze Allocated QA Req'ts
Perform Analysis & Control
Perform Measurement & Anal
Implement Quality Controls & Improvement Processes
Assess Design Solutions for Consistency with Req'ts
Support Failure Analyses
Support Req'ts Dev
Ensure Adequacy of V&V Methods, Process Stds
Facilitate/Support Tech Forums
Design Solution
Support Trades, Design Analyses for Balanced Solution
Advance Technologies Thru Analyses, Prototyping, Demos
Support CPD Development
Identify/Assess V&V Resources, Methods, Procedures, Results, Technical Rqmts and Architecture Baseline
Manage QA Element of System Design /Rqmts Modifications
Ensure QA Controls of Modeling Based V&V Methods / Procedures
Identify/Assess V&V Methods, Procedures, Results
Ensure Baseline Products & Data Align with Specifications (Requirements)
Support Sustainment Analyses and Evaluate Operational Performance – to Determine Adequacy of Quality Controls & Improvement Opportunities
Continue to Conduct Quality Reviews as Required
Support Program Progress Reviews
Continue to Support PMPCB, MRB, JRMET, FRACAS, GIDEP Alert Assessments
Provide Updates to Baseline Products, Acq Program Docs: APB, CARD, CPD, TEMP, Arch Artifacts, etc
Support RFP Development & Proposal Evaluation Activities for Changes and Follow-on Contracts
Provide Program and Technical Compliance Req'ts & Essential Quality Controls
Provide Modeling Validation Approaches, Incentives to Meet Quality Objectives
Provide Quality V&V Req'ts
For Major Modifications: Provide Updates to Quality Engr & Controls Products, Acq Program Docs
Support RFP Development & Proposal Evaluation Activities for Changes and Follow-on Contracts
Provide Program and Technical Compliance Req'ts & Essential Quality Controls
Provide Modeling Validation Approaches, Incentives to Meet Quality and Program Objectives
Provide Quality V&V. Stipulate Contractual Risk Mitigations
Assess Contractors' & Subs Compliance to Contractual/ Tech Requirements – Req'ts Flow-down
Assess Adequacy and Validation of Models, Simulations Used
Assess Adequacy of Design Analyses, Trades and Contractors' Effectiveness to Design for Quality, Manufacturing and Producibility, etc
Assess Effectiveness of Problem ID and Corrective Action Programs
Assess Contractors' V&V Procedures & Results: Analyses, Tests, Demos
Disseminate QA & Tech Data Among Stakeholders
Assess Contractors and Subs' Compliance to Req'ts
Assess Adequacy of Integration Procedures and Models / Simulations Used
Review Contractors' Tech Data (Arch Products, Tech Manuals, Specs, Drawings, Test Procedures, COQ Procedures
Assess Test & Demo Procedures, Monitor Test / Simulations Activities, Assess Results
Assess Effectiveness of Process Control & Problem ID & C/A Process
Ensure Contractors' Design Activities are Integrated with the Overall SE Program
Disseminate Tech Data Among Stakeholders

2. **Technology Development.** During the Technology Development Phases the QAE provides inputs to and supports and updates to the cost model and development of the Cost Analysis Requirements Description (CARD), solicitation/RFP development and proposal evaluation activities. The QAE identifies other contract requirements that influence or impact product and performance quality such as incentives/warranty programs, quality of design requirements to meet QA objectives; progress and performance measurements and metrics. The QAE also contributes to the development and updates to the TD Phase acquisition products as noted in the table. During this phase, the QAE assesses the systems, subsystems, components, and system operations, and maintenance concepts to determine and address deficiencies or quality related risks. The QAE ensures reliability, hazards, safety, security analysis and other analyses that indicate deficiencies are completed, and program-unique risks are identified and mitigations implemented to eliminate or reduce the severity of the risks. The QAE also ensures that the effectiveness of mitigation measures is verified.

TD Phase – SMC Acquisition Products
Updates to ASP, TDS, DMS
LC Cost Estimate Update / CARD Development
RFP: QA objectives in the SOO; QA related tasks in SOW, QA data products in CDRLs; SMC- QA standards - tailored
SSP: evaluation criteria for QA
APB: QA objectives & related concept descriptions
Detailed QA planning, SEP, LCMP, TEMP

3. **Engineering & Manufacturing Development.** During the EMD Phase the updates the cost model to reflect the actual technical solutions determined and updates to the CARD. The QAE supports the solicitation/RFP development and proposal evaluation activities which include providing the technical inputs including technical QA requirements, QA compliance standards, QA engineering and process control approaches, incentives, and warranty programs to meet program objectives. The QAE also contributes to the development and updates to the EMD Phase acquisition products as noted in the table.

EMD Phase – SMC Acquisition Products
Updates to ASP, TDS, DMS
CARD update
RFP: QA objectives in the SOO; QA related tasks in SOW, QA data products in CDRLs; SMC- QA standards – tailored; QA program and system quality requirements; Inspection, calibration/meteorological, audit, requirements
SSP: evaluation criteria for QA
APB: QA objectives & concept descriptions that relate to QA
Detailed QA Program Office and Contractor planning, SEP, LCMP, TEMP updates

4. **Production & Deployment, Operations & Support.** The QAE continues to provide QA inputs to all program acquisition activities including updates to the acquisition strategy and the cost model to reflect the actual technical solutions, program office decisions, and updates to the CARD as the system evolves. The QAE supports the solicitation/RFP development and proposal evaluations. The QAE identifies other contract requirements: production process capability analysis (in conjunction with the Manufacturing Engineer), critical tests and inspections requiring QA verification. The QAE formulates QA incentives/warranty programs; as well as requirements for packaging and inspection/test on delivery of contracted items being tendered for government acceptance.

P&D / O&S Phase – SMC Acquisition Products
Updates to ASP, TDS, DMS
RFP: QA objectives in the SOO; QA related tasks in SOW, QA data products in CDRLs; SMC- QA standards – tailored; QA program and system quality requirements; Inspection, calibration/meteorological, audit, requirements
SSP: evaluation criteria for QA
Detailed QA planning, SEP, LCMP, TEMP updates
CARD update

QAE Contributions to the Engineering Life Cycle Framework

Relationship to the SE Organization

The QAE plans and executes essential quality assurance and quality engineering/management efforts within the context and in full support of the overarching Systems Engineering function. The QAE ensures that the program QA planning is complete and each QA SED contribution is timely, adequate, consistent, and compliant. The QAE ensures that their contributions are channeled through the Systems Engineering *Analyses and Control* activity.

Systems Engineers manage the engineering process and activities depicted in Figure 3 while the QAE contributes to this process. The QAE develops/derives the program specific QA requirements and supports the requirements analyses and allocations process. They also participate in technical studies and solutions trades when quality assurance disciplines are a factor. They maintain a close liaison with the design engineers and provide design analyses contributions to determine and adjust the appropriate level of quality requirements through analyses, demo, inspection, and test.

The QAE works closely with: System Engineers performing interface analyses, functional analyses, and the integration, verification and validation planning and execution; Software Engineers to oversee software development, they are typically designated as Software Quality Assurance (SQA) or Software Quality Engineers (SQE); the Reliability and Maintainability (RAM) Engineer to ensure quality and reliability through controlled and predictable quality levels during production, handling, storage, packaging, and transportation.

In performing the management and control function, the SE effectively integrates all engineering functions through the full system life cycle. The QAE ensures that effective informational and statistical quality assurance techniques and advances are appropriately applied through systematic control, collaboration and sharing across the organization. For example, the major quality system indicators i.e.; Process Capability (Cpk), Process Cycle Efficiency (the key lean metric), Cost of Quality (COQ), MRB's, FRB's, Major Defect and Corrective/ Preventive Actions, must be routinely evaluated and reviewed at Program Reviews to assure the Quality Program is yielding a high level of quality which is being sustained by both acquisition specialists and contractor organizations, including subcontractors.

Relationship to other SEDs

The QAE ensures their technical contribution to the overall systems engineering is appropriately applied through systematic control, collaboration and sharing across the organization. Since a do-it-right-the-first-time mindset must be realized by all acquisition specialists, the QAE works closely with other specialty engineers in accomplishing the quality expectations. In addition, the QAE products and metrics are timed and applied by the other Specialty Engineers to perform their unique contributions, and must be provided to technical and program management for decision making.

The QAE works closely with the Manufacturing Engineer, and RAM Engineer to identify and assess process and workmanship concerns that may potentially impact product quality and reliability; and to review process improvement opportunities with the contractor.

Tools Selection and Use

The QAE evaluates the choice of QA tools for effectiveness and efficiencies that are used for QA system analyses, T&E, information sharing, automated data exchanges with other tools, and other considerations.

Typical QA Functions Requiring Tools
Cost of Quality (COQ)
QA Requirements Analyses & Allocations
Process Capability (Cpk)
Process Cycle Efficiency
Major Defects Pareto Chart
Software Defect Tracking System
Corrective/Preventive Actions

Engineering Activities and Products over the Life Cycle

The following subsections delineate QAE contributions to engineering activities and technical products for each DoD acquisition phase. Refer to SMC-S-003 for a more complete description of QA activities that are performed by the Program Office and their contractors.

1. **Materiel Solution Analysis.** During the MSA phase the QAE may provide inputs to and support the Capabilities Based Assessment process and the JCIDS process. The QAE also contributes to the development of the MSA Phase technical products as noted in the Table.

MSA Phase – Technical Products Required	
SMC QA Technical Products	QA Contributions to Other Organizations' Products
High level QA req'ts analysis	Operational Concepts
QA inputs & factors for concept, arch technology studies& trades	AoA Studies
QA System Req'ts (draft)	Initial Capabilities Doc (ICD) Dev
Roadmap inputs – mitigations of critical process points/ risks	DoDAF CVs, OVs

2. **Technology Development.** During the TD phase the QAE continues to provide inputs to and supports the JCIDS process. The QAE also supports all the engineering activities highlighted within the box titled *Engineering Activities for System & Segment Development & Design* Figure 9 to commence system definition and development. The QAE contributes to development of the TD Phase technical products as noted in the Table.

TD Phase – Technical Products Required	
SMC QA Technical Products	QA Contributions to Other Organizations' Products
Inputs to System Concepts	Operational Concepts
Factors for QA applications	Operational Assessments
QATech Req'ts, TRD, SRD, Specifications, ICDs, Standards Selection/ Tailor	Capabilities Development Doc (CDD) PDRs, CDRs
QA inputs to ISP	DoDAF CVs, OVs
QA Program Analysis Reports	Compliance Audits

3. **Engineering & Manufacturing Development.** The QAE continues to provide inputs to and support the JCIDS process. The QAE supports all the engineering activities highlighted within the box titled *Engineering Activities for Detailed Design* Figure 9 to commence detailed systems definition and development. The QAE establishes a closed-loop defect/deficiency reporting system across Contractors, stakeholders and other discrepancy reporting/analysis & corrective action contributors.

EMD Phase – Technical Products Required	
SMC QA Technical Products	QA Contributions to Other Organizations' Products
Update System Concept	Operational Concepts
Validate QA applications	Operational Assessments
QA System Tech Req'ts, TRD, SRD, Spec, ICDs	Capabilities Production Doc (CPD)
Inputs to system, production, fielding, sustain design docs	Mfg Readiness Reviews, Test Readiness Reviews
QA inputs to ISP	DoDAF CVs, OVs
QA Program Analysis Reports	Compliance Audits
Process Capability Reports	Contractor assessments

The activities of the QAE during this phase are extensive. Refer to the SMC-S-003 QA Guide for QAE activities and products typically required during each phase. The QAE develops and contributes to the development of the EMD Phase technical products to assure a high level of manufactured-in quality.

4. **Production & Deployment, Operations & Support.** The QAE continues to provide inputs to and supports the JCIDS process during the P&D/O&S phase. The activities of QA during this phase are extensive. Refer to the SMC-S-003 Quality Assurance Guide for QA activities and products typically required during each phase. The QAE develops and contributes to the development of the P&D / O&S Phase technical products as noted in the Table.

P&D / O&S Phase – Technical Products Required	
SMC QA Technical Products	QA Contributions to Other Organizations' Products
Inputs to tech baseline/ engineering changes	Supportability Analyses Rpt
Analyses of production quality reports and test reports	Operational Assessments Hardware Acceptance Reviews
Transition & Fielding Docs	Logistics Reports
QA Analyses Reports; Process capability & cycle efficiency reports	Management System Reviews
COQ Reports	Financial Assessments

QAE Contributions to Program and Project Management

Each SMC program defines their business model and approach structure based primarily on the unique aspects of each project. These factors include: program objectives, program and technical challenges, organizational structure, as well as program and engineering planning (SEP plus detailed RAM planning).

The QAE develops and implements the QA program plan to achieve QA objectives and requirements. The planning defines the QA tasks and functions to be performed and products to be developed; timing of tasks, task outputs, resources (skills, tools, equipment), and completion criteria. The QAE plans tasks to integrate QA activities within the program office, between Contractors and stakeholders. The QAE plans the tasks to establish and manage the QA program; support SE&I activities, e.g., production process controls, V&V activities, risk management, integration, system modifications, contractor compliance verification requirements; coordinate the QA planning with the SMC QA OPR, operating commands, supporting commands, and test agencies; and integrate QA planning with other functional and acquisition plans (i.e. SEP, ASP, LCMP).

SMC Program Management Products
PMD
SEP, IMP, IMS, WBS
Decision-making & problem solving inputs
Technical progression and issues reporting
LC Cost Estimate (CARDs)
Processes (OIs)
Risk Management Inputs

Execution of the QA plan is typically defined through an Operating Instruction (OI). The QAE provides full support to define the program and technical objectives where quality assurance and engineering should be applied. The QAE assists to establish the business model, develop program planning and schedules, and define and implement program processes. The QAE ensures the QA components of the program are appropriately represented in the program plans, program schedules, work breakdown schedules, and cost estimates. The QAE also reports their assigned program's technical performance and progress. The QAE supports the program manager's problem identification, resolution, and decision-making processes by providing: program quality performance assessments, contractor cost of quality and deficiency identification reports and assessments as available, evaluations of contractor and DCMA system audit results, preparing and executing Program Office/DCMA

MOAs and maintaining interaction with contractor QA Management and DCMA QA personnel. The QAE contributes QA inputs for the development of the program management products identified in the Table.

Appendix G – Reliability, Availability and Maintainability

The SMC Program Office Reliability, Availability & Maintainability (RAM) Engineers have the responsibility to stand-up and execute the RAM program. The RAM Engineer plans and executes the essential RAM engineering and management efforts in an integrated and effective manner to ensure that each RAM SED contribution is timely, adequate, consistent, and compliant. The RAM Engineer ensures that their contributions are channeled through the Systems Engineering *Analyses and Control* activity.

Applicable governance, standards, and guidance

Policy, directives, and instructions that mandate RAM engineering related program requirements are included in a wide range of mandates including those providing requirements for acquisition, T&E, software, Systems Engineering, and others. Table 12 below identifies the significant governance, standards, and guidance which generally require SMC compliance for RAM.

Table 12 Governance, standards, and guidance that shape the RAM engineering discipline

Document No	Governance Title	Issue
DoDI 5000.02	Operation of the Defense Acquisition System	08 Dec 08
CJCSM 3170.01	Operation of the Joint Capabilities Integration and Development System	24 Jun 03
AFI 10-601	Capabilities Based Requirements Development	30 Jul 04
AFI 21-108	Maintenance Management of Space Systems	25 Jul 94
AFI 21-118	Improving Air and Space Equipment RAM	02 Oct 03
AFI 63-1201	Life Cycle Systems Engineering	23 Jul 07
SMCI 62-001	Reliability And Maintainability	11 Apr 07
Document No	**Standards Title**	**Issue**
SMC-S-013	Reliability Program For Space Systems	13 Jun 08
Mil-Std-785B	Reliability Program For Systems And Equipment Development And Production	03 Jul 86
Document No	**Guidance Title**	**Issue**
	DoD Guide For Achieving Reliability, Availability, And Maintainability	03 Aug 05
	DoD Reliability, Availability, Maintainability, Cost Rationale Report Manual	01 Jun 09
MIL-HDBK-217	Reliability Prediction of Electronic Equipment	28 Feb 95
CPATS	Critical Process Assessment Tool – Reliability Engineering	14 Aug 98
RAIC	Rome Laboratory Reliability Engineer's Toolkit	Apr 93

RAM Engineers' Contributions to the Acquisition Life Cycle Framework

The DoD acquisition life cycle is defined by DoDI 5000.02. RAM Engineer contributions over this life cycle are best represented within the phase of acquisition. Figure 10 provides the acquisition life cycle framework within which RAM Engineers perform as well as the products that the RAM Engineers must develop or contribute to their development. This figure along with SMCI 62-001, Sections 4 and 5 requirements to perform RAM planning, support pre and post contract award acquisition activities, and perform RAM management and engineering across the system lifecycle. SMC Program Offices establish and implement RAM program strategies and objectives consistent with the tenets of appropriate policies, SMC acquisition objectives, and program objectives. The Program Office then develops, attains approval for, and implements RAM planning into the Systems Engineering Plan (SEP) and higher level integrated planning (e.g., IMP) in accordance with current DoD policy. This planning is firmly based on program and technical objectives, strategies, DoD mandates, and instructions.

An effective RAM program supports all of the major acquisition activities through the full system life cycle. The planning sufficiently defines the RAM program to achieve the RAM and overall program objectives and requirements; specifies tasks and functions to be performed, timing of tasks, resources required, products to be developed, and forms the basis for the development of the program RAM Operating Instruction (OI). The RAM planning and OI are then reflected appropriately in the WBS, IMS, and other program documents that address RAM related elements. The RAM planning is executed concurrently with the Program Office OI that documents the process to perform, control, and integrate all RAM engineering and management activities for each phase of acquisition. The SMC Program Office RAM planning (usually contained in the SEP and the detailed RAM program planning) and OI are be based upon the appropriate program-approved life cycle. SMC Program Offices appoint establish and implement RAM program strategies and objectives consistent with the tenets of appropriate policies, SMC acquisition objectives, and program objectives.

1. **Materiel Solution Analysis.** During this phase the RAM Engineer provides inputs to and supports most program acquisition activities to include the development of the acquisition strategy, inputs to cost estimates, solicitation/RFP development for Contractor studies, and proposal evaluation activities. The RAM Engineer also contributes to the development of the MSA Phase acquisition products.

MSA Phase – SMC Acquisition Products
RAM-C Report (Attached to AoA)
ASP, TDS, DMS, TES
LC Cost Estimate
RFP inputs (RAM mission/operational/ system requirements; RAM Assessment requirements; High level reliability formulations
APB, CCA
SSP, SEP

2. **Technology Development.** The RAM Engineer provides inputs to and supports all program acquisition activities to include the development of the acquisition strategy, updates to the cost model and development of the Cost Analysis Requirements Description (CARD), solicitation/RFP development and proposal evaluation activities. The RAM Engineer identifies other contract requirements such incentives/warranty programs and test & demo requirements to meet RAM objectives. The RAM Engineer also contributes to the development and updates to the TD Phase acquisition products.

TD Phase – SMC Acquisition Products
Updates to ASP, TDS, DMS, LCSP with RAM-C
LC Cost Estimate Update / CARD Development
RFP: RAM objectives in the SOO; RAM related tasks in SOW, RAM data products in CDRLs; SMC- RAM standards - tailored
SSP: evaluation criteria for RAM
APB: RAM objectives & related concept descriptions
Detailed RAM planning, SEP, TEMP

3. **Engineering & Manufacturing Development.** The RAM Engineer provides inputs to and supports all program acquisition activities to include updates to the acquisition strategy and updates to the cost model to reflect the actual technical solutions determined and updates to the CARD. RAM Engineer supports the solicitation/RFP development and proposal evaluation activities which include providing the technical inputs including technical requirements, compliance standards, engineering approaches, incentives, and warranty programs to meet program objectives. The RAM Engineer identifies other contract requirements such incentives/warranty programs and prototype and engineering qualification unit reliability related test &

EMD Phase – SMC Acquisition Products
Updates to ASP, TDS, DMS, LCSP with RAM-C
CARD update
RFP: RAM objectives in the SOO; RAM related tasks in SOW, RAM data products in CDRLs; SMC- RAM standards - tailored
SSP: evaluation criteria for RAM
APB: RAM objectives & related concept descriptions
Detailed RAM planning, SEP, TEMP updates

requirements to meet RAM objectives. RAM Engineer also contributes to the development and updates to the EMD Phase acquisition products.

4. **Production & Deployment, Operations & Support.** The RAM Engineer provides inputs to and supports all program acquisition activities to include updates to the acquisition strategy and updates to the cost model to reflect the actual technical solutions determined and updates to the CARD. RAM Engineer supports the solicitation/RFP development and proposal evaluation activities. The RAM Engineer identifies other contract requirements: incentives/warranty programs; production and field test & demo requirements; field performance and sustainment analyses to meet RAM objectives.

P&D / O&S Phase – SMC Acquisition Products
Updates to ASP, TDS, DMS, LCSP with RAM-C
RFP: RAM objectives in the SOO; RAM related tasks in SOW, RAM data products in CDRLs; SMC- RAM standards - tailored
SSP: evaluation criteria for RAM
Detailed RAM planning, SEP, TEMP updates
CARD update

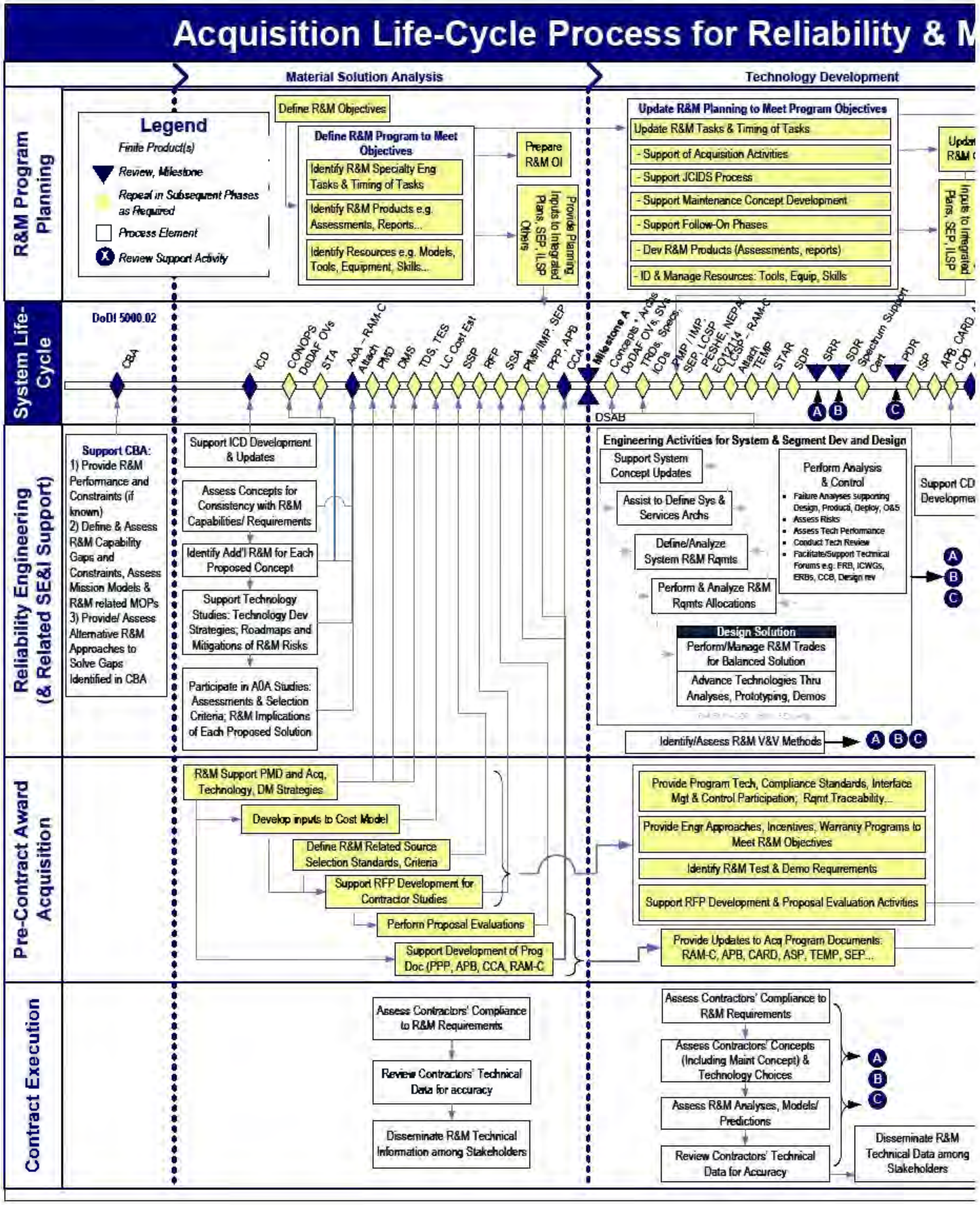
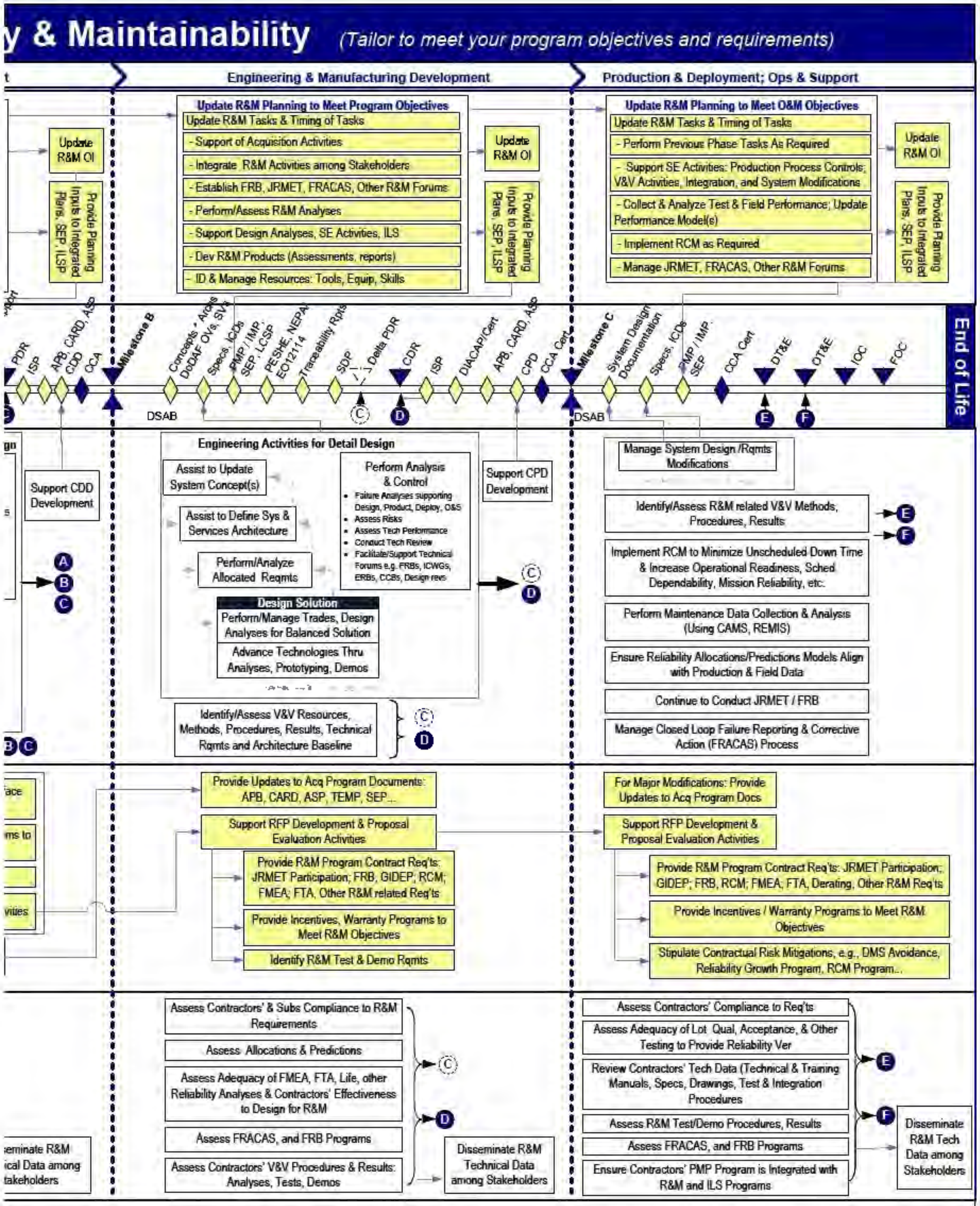


Figure 10 Acquisition life cycle process for SMC RAM Engineering



y & Maintainability (Tailor to meet your program objectives and requirements)
Engineering & Manufacturing Development
Production & Deployment; Ops & Support
Update R&M Planning to Meet Program Objectives
Update R&M Tasks & Timing of Tasks
- Support of Acquisition Activities
- Integrate R&M Activities among Stakeholders
- Establish FRB, JRMET, FRACAS, Other R&M Forums
- Perform/Assess R&M Analyses
- Support Design Analyses, SE Activities, ILS
- Dev R&M Products (Assessments, reports)
- ID & Manage Resources: Tools, Equip, Skills
Update R&M OI
Provide Planning Inputs to Integrated Plans, SEP, ILSP
Update R&M Planning to Meet O&M Objectives
Update R&M Tasks & Timing of Tasks
- Perform Previous Phase Tasks As Required
- Support SE Activities: Production Process Controls; V&V Activities, Integration, and System Modifications
- Collect & Analyze Test & Field Performance; Update Performance Model(s)
- Implement RCM as Required
- Manage JRMET, FRACAS, Other R&M Forums
End of Life
PDR
ISP
APB, CARD, ASP
CDD
CCA
Milestone B
DSAB
Concepts • Arch
DoDAF OVs, SVs
Specs, ICDs
PMP / IMP, SEP, LCSP
PESHE, NEPA/ EO12114
Traceability Rpts
SDP
Delta PDR
CDR
ISP
DIACAP/Cert
APB, CARD, ASP
CPD
CCA Cert
Milestone C
System Design Documentation
Specs, ICDs
PMP / IMP, SEP
CCA Cert
DT&E
OT&E
IOC
FOC
Support CDD Development
Engineering Activities for Detail Design
Assist to Update System Concept(s)
Assist to Define Sys & Services Architecture
Perform/Analyze Allocated Reqmts
Perform Analysis & Control
Failure Analyses supporting Design, Product, Deploy, O&S
Assess Risks
Assess Tech Performance
Conduct Tech Review
Facilitate/Support Technical Forums e.g. FRBs, ICWGs, ERBs, CCBs, Design revs
Design Solution
Perform/Manage Trades, Design Analyses for Balanced Solution
Advance Technologies Thru Analyses, Prototyping, Demos
Support CPD Development
Identify/Assess V&V Resources, Methods, Procedures, Results, Technical Rqmts and Architecture Baseline
Manage System Design /Rqmts Modifications
Identify/Assess R&M related V&V Methods, Procedures, Results
Implement RCM to Minimize Unscheduled Down Time & Increase Operational Readiness, Sched Dependability, Mission Reliability, etc.
Perform Maintenance Data Collection & Analysis (Using CAMS, REMIS)
Ensure Reliability Allocations/Predictions Models Align with Production & Field Data
Continue to Conduct JRMET / FRB
Manage Closed Loop Failure Reporting & Corrective Action (FRACAS) Process
Provide Updates to Acq Program Documents: APB, CARD, ASP, TEMP, SEP...
Support RFP Development & Proposal Evaluation Activities
Provide R&M Program Contract Req'ts: JRMET Participation; FRB, GIDEP; RCM; FMEA; FTA, Other R&M related Req'ts
Provide Incentives, Warranty Programs to Meet R&M Objectives
Identify R&M Test & Demo Rqmts
For Major Modifications: Provide Updates to Acq Program Docs
Support RFP Development & Proposal Evaluation Activities
Provide R&M Program Contract Req'ts: JRMET Participation; GIDEP; FRB; RCM; FMEA; FTA, Derating, Other R&M Req'ts
Provide Incentives / Warranty Programs to Meet R&M Objectives
Stipulate Contractual Risk Mitigations, e.g., DMS Avoidance, Reliability Growth Program, RCM Program...
Assess Contractors' & Subs Compliance to R&M Requirements
Assess Allocations & Predictions
Assess Adequacy of FMEA, FTA, Life, other Reliability Analyses & Contractors' Effectiveness to Design for R&M
Assess FRACAS, and FRB Programs
Assess Contractors' V&V Procedures & Results: Analyses, Tests, Demos
Disseminate R&M Technical Data among Stakeholders
Assess Contractors' Compliance to Req'ts
Assess Adequacy of Lot Qual, Acceptance, & Other Testing to Provide Reliability Ver
Review Contractors' Tech Data (Technical & Training Manuals, Specs, Drawings, Test & Integration Procedures
Assess R&M Test/Demo Procedures, Results
Assess FRACAS, and FRB Programs
Ensure Contractors' PMP Program is Integrated with R&M and ILS Programs
Disseminate R&M Tech Data among Stakeholders

RAM Engineers' Contributions to the Engineering Life Cycle Framework

Relationship to the SE Organization

The RAM Engineer plans and executes essential RAM engineering and engineering management efforts in an integrated and effective manner within the context and full support of the overarching Systems Engineering function. The RAM Engineer ensures that each RAM SED contribution is timely, complete, consistent, and compliant. The RAM Engineer ensures that their contributions are channeled through the Systems Engineering *Analyses and Control* activity. Systems Engineers manage the engineering process and activities depicted in Figure 3 while the RAM Engineer contributes to this process. The RAM Engineer supports concept and architecture development and analyses; modeling and simulation efforts; and technology studies. The RAM Engineer develops/derives their requirements and supports the requirements analyses and allocations process. They also participate in technical studies and solutions trades when reliability and/or maintainability are a factor. They provide design analyses contributions to determine and validate reliability allocations, update reliability predictions, and ensure confidence in attaining RAM requirements through analyses, demo, and test.

The RAM Engineer also works closely with the System Engineers performing interface analyses, functional analyses, and the integration and verification and validation planning and execution. The Reliability Engineer works closely with the Logistics Engineers performing maintenance and sustainment analyses. The Reliability Engineer aligns closely with the Quality Assurance and Quality Engineer to ensure reliability through controlled and predictable quality levels during production, handling, storage, packaging, and transportation.
In performing the management and control function, the SE effectively integrates all engineering functions through the full system life cycle. The RAM Engineer ensures their technical information advances and is appropriately applied through systematic control, collaboration and sharing across the organization. For example, their analytical products (e.g., fault tree, failure modes, critical items lists, reliability block diagrams, etc) must be timed and applied by the other Specialty Engineers to perform their unique contributions, and must be provided to technical and program management for decision making.

Relationship to other SEDs

The RAM Engineer ensures their technical contribution to the overall engineering advances and is appropriately applied through systematic control, collaboration and sharing across the organization. For example, their failure analysis products are timed to coincide with hazards analyses, HSI analysis, architectural trades, design trades, and supportability analysis. In addition the RAM Engineers products are timed and applied by the other Specialty Engineers to perform their unique contributions, and must be provided to technical and program management for decision making.
The RAM Engineer works closely with the Logistics Engineers to determine maintenance needs for system elements prone to failures. The RAM Engineer works closely with QA/QE specialists to identify and assess process and workmanship concerns that may potentially impact system reliability.

Tools Selection and Use

The RAM Engineer considers effectiveness and efficiencies gained by selecting and using the best choice of RAM tools considering the RAM tool requirements possibly for RAM formulations, modeling, predictions, reliability analyses, T&E, information sharing, automated data exchanges with other tools, and other considerations.

Typical RAM Functions Requiring Tools
Modeling & Predictions
RAM Requirements Analyses & Allocations
Experiment Design, Growth, and Life Data Analysis
Accelerated Life Testing; System Analysis: RBDs & Fault Trees
Reliability Centered Maintenance
FMEA

Engineering Activities and Products over the Life Cycle

The following subsections delineate RAM contributions to engineering activities and technical products by DoD acquisition phase. Refer to SMC-G-002 for a more complete list of RAM Engineering activities and products that are prepared by the Program Office and their Contractors.

1. **Materiel Solution Analysis.** During this phase the RAM Engineer may provide inputs to and support the Capabilities Based Assessment process and the JCIDS process. The RAM Engineer also contributes to the development of the MSA Phase technical products.

MSA Phase – Technical Products Required	
SMC RAM Technical Products	Contributions to Other Organizations' Products
High level reliability analysis	Operational Concepts
RAM inputs and factors for concept, architecture, technology studies, and trades	AoA Studies
System RAM Req'ts (draft)	Initial Capabilities Doc (ICD) Dev
Roadmap inputs – mitigations of RAM risks	DoDAF CVs, OVs

2. **Technology Development.** During this phase the RAM Engineer continues to provide inputs to and supports the JCIDS process. The RAM Engineer also supports all the engineering activities highlighted within the box titled *Engineering Activities for System & Segment Development & Design* Figure 10 to commence system definition and development. RAM Engineer develops and contributes to development of the TD Phase technical products.

TD Phase – Technical Products Required	
SMC RAM Technical Products	Contributions to Other Organizations' Products
Inputs to System Concepts	Operational Concepts
Factors for Studies/ Trades	Operational Assessments
RAM Tech Req'ts, TRD, SRD, Specifications, ICDs, Standards Selection/ Tailor	Capabilities Development Doc (CDD)
RAM inputs to ISP	DoDAF CVs, OVs
RAM Analyses Rpts	

3. **Engineering & Manufacturing Development.** RAM Engineer continues to provide inputs to and support the JCIDS process. The RAM Engineer supports all the engineering activities highlighted within the box titled *Engineering Activities for Detailed Design* Figure 10 to commence detailed systems definition and development. The RAM Engineer establishes a closed-loop failure reporting system across Contractors, stakeholders and other failure reporting/analysis & corrective action contributors. The RAM Engineer establishes JRMET to assist in collecting, analyzing, and categorizing RAM data during DT&E inputs to and supports the JCIDS process. The activities of RAM during this phase are extensive. Refer to the SMC-G-002 RAM Guide for RAM Engineer activities and products typically required during each phase. RAM Engineer develops and contributes to the development of the EMD Phase technical products.

EMD Phase – Technical Products Required	
SMC RAM Technical Products	**Contributions to Other Organizations' Products**
Update System Concept	Operational Concepts
Technical Studies/ Trades	Operational Assessments
System Tech Req'ts, TRD, SRD, Spec, ICDs; RAM allocations	Capabilities Production Doc (CPD)
Inputs to system, production, fielding, sustain design docs	
RAM inputs to ISP	DoDAF CVs, OVs
RAM Analyses Rpts, RBD, models, predictions	
Test, Demo reports	

4. **Production & Deployment, Operations & Support.** RAM Engineer continues to provide inputs to and supports the JCIDS process. The activities of RAM during this phase are extensive. Refer to the SMC-G-001 RAM Guide for RAM Engineer activities and products typically required during each phase. The RAM Engineer develops and contributes to the development of the P&D / O&S Phase technical products.

P&D / O&S Phase – Technical Products Required	
SMC RAM Technical Products	**RAM Contributions to Other Organizations' Products**
Inputs tech baseline engineering changes	Supportability Analyses Rpt
Analyses of production quality reports and test reports	Operational Assessments
Transition & Fielding Docs	
RAM Analyses Rpts; Reliability And Maintainability Information System Assessments (REMIS)	
V&V / T&E Reports	

RAM Engineers' Contributions to Program and Project Management

Each SMC program defines their business model and approach structure based primarily on their program objectives, program and technical challenges, organizational structure, as well as program and engineering planning (SEP plus detailed RAM planning).

The RAM Engineer develops and implements the RAM program planning to achieve RAM objectives and requirements. The planning defines the RAM tasks and functions to be performed and products to be developed; timing of tasks, task outputs, resources (skills, tools, equipment, and completion criteria. The RAM Engineer plans tasks to integrate RAM activities within the program office, between Contractors and stakeholders. The RAM Engineer plans the tasks to establish and manage the JRMET, FRACAS, and other RAM related forums; support SE&I activities, e.g., production process controls, V&V activities, risk management, integration, and system modifications; coordinate the RAM planning with SMC RAM Official Person Responsible (OPR), operating commands, supporting commands, and test agencies; and integrate RAM planning with other functional and acquisition plans (i.e. SEP, ASP, LCMP).

Execution of the RAM planning is typically defined through an Operating Instruction (OI). The RAM Engineer provides full support to define the program and technical objectives where RAM challenges and risks are known or anticipated. The RAM Engineer assists to establish the business model, develop program planning and schedules, and define and implement program processes. The RAM Engineer ensures the RAM components of the program are appropriately represented in the program plans, program schedules, work breakdown schedules, cost estimates. The RAM Engineer also reports their technical performance and progress. The RAM Engineer shares in the risk management responsibilities to identify, assess, and propose mitigating actions of RAM related risks. They also support the program manager's problem identification, resolution, and decision-making processes.

The RAM Engineer contributes to the development of the program management products identified in the Table.

SMC Program Management Products
PMD
SEP, IMP, IMS, WBS
Decision-making & problem solving inputs
Technical progression and issues reporting
LC Cost Estimate (CARDs)
Processes (OIs)
Risk Management Inputs

Appendix H – Spectrum Management

Spectrum Management (SM) is that discipline that pertains to the planning, engineering, administration and coordination for the joint use of the range of frequencies of electromagnetic (EM) radiation by subsystems and equipment that radiate or receive EM energy. This range of frequencies, which is divided into 26 alphabetical bands, is a natural resource within national and international boundaries. Advances in modern technologies in recent years and a shift in joint warfighting strategies have demonstrated a proliferation of potential conflicts resulting from the increased use of the EM spectrum by both government and non-government users. As a result, the requirement for proper analyses and management of the use of the spectrum has risen exponentially in response to the increasing demand for its application.

The SMC Program Office SM POC is the designated authority responsible for establishing and executing the SM program. A SM POC is an individual appointed as the representative of the Program Office to manage its affairs. The SM POC is also responsible for planning, administering and ensuring essential SM engineering and management efforts are integrated with the various acquisition, management, & engineering activities. In addition, the SM ensures adherence to effective and compliant contributions with respect to the various policies, DoD mandates, instructions, and SMC acquisition program and technical objectives, while implementing the program strategies and plans within the POC's realm of responsibilities.

Applicable governance, standards, and guidance

SM related program requirements are delineated throughout a broad range of mandates including public law, policies, directives, and instructions. These requisite requirements also interrelate with various disciplines including acquisition, information assurance, and Systems Engineering to name a few. Table 13 below identifies the significant governance which generally requires SMC compliance for SM. At the time of this writing, an SMC Instruction is in progress to more clearly promulgate the scope, responsibilities, procedures and requirements of the SM office as it pertains to the various acquisition, management and engineering lifecycles.

Table 13 Governance, standards, and guidance that shape the Spectrum Management Engineering Discipline

Document No	Governance Title	Issue
Public Law Number 416, Ch 5,Title 47 of US Code	The Communications Act of 1934	19 Jun 34
Public Law 102-538, 106 Stat. 3533 (codified at 47 U.S.C. 901 et seq.)	The National Telecommunications and Information Organization Act, "Spectrum Management Activities"	92
	DoD Net-Centric Spectrum Management Strategy	03 Aug 06
DoDD 5000.01	The Defense Acquisition System	12 May 03
DoDD 5100.35	Military Communications-Electronics Board (MCEB)	10 Mar 98
DoDD 4630.8	Procedures for Interoperability & Supportability of Information Technology (IT) and National Security Systems (NSS)	30 Jun 04
DoDD 3222.3	DoD Electromagnetic Environmental Effects (E3) Program	08 Sep 04
DoDI 5000.02	Operation of the Defense Acquisition System	08 Dec 08
DoDI 4650.1	Policy and Procedures for the Management and Use of the Electromagnetic Spectrum	09 Jan 09
CJCSM 3170.01	Operation of the Joint Capabilities Integration and Development System	01 May 07
CJCSI 6212.01E	Interoperability and Supportability of Information Technology and National Security Systems	15 Dec 08

NTIA Manual	Department of Commerce (DoC) National Telecommunications and Information Administration (NTIA) Manual of Regulations and Procedures for Federal Radio Frequency Management	May 10 (Revision)
AFPD 16-2	Disclosure of Military Information to Foreign Governments and International Organizations	10 Sep 93
AFPD 33-1	Information Resources Management	27 Jun 06
AFPD 61-2	Management of Scientific and Technical Information	07 Apr 93
AFI 10-707	Spectrum Interference Resolution Program	20 Jun 05
AFI 31-401	Information Security Program Management	01 Nov 05
AFI 33-106	Managing High Frequency Radios, Personal Wireless Communication Systems, And The Military Affiliate Radio System	09 Jan 02
AFI 33-118	Electromagnetic Spectrum Management	18 Jul 05
OMB Circular A-11	Preparation, Submission and Execution of The Budget	Aug 09
	ITU Radio Regulations	04
Document No	**Standards Title**	**Issue**
Mil-Std-449D	Radio Frequency Spectrum Characteristics Measurement of	22 Feb 93
MIL-STD-461F	Electromagnetic Emissions and Susceptibility, Requirements for the Control of Electromagnetic Interference	10 Dec 07
Mil-Std-464A	Electromagnetic Environmental Effects Requirements For Systems	19 Dec 02
Document No	**Guidance Title**	**Issue**
Allied Communications Pub 190C, U.S. Sup 1	Guide to Spectrum Management in Military Operations	Sep 07
DAG, Chapter 7.6	The Defense Acquisition Guidebook, The Electromagnetic Spectrum	05 May 10
AFMAN 33-120	Electromagnetic Spectrum Management	19 Sep 06
MIL-HDBK-237C	Electromagnetic Environmental Effects and Spectrum Supportability Guidance For The Acquisition Process	20 May 05

With regards to advancements in technological innovations and rising demand for the use of the electromagnetic spectrum from new technologies such as wireless systems, the SM concept complies with classic economic principles. The rise in demand results in a decline of supply and vice versa. In other words, more systems occupying real estate on the frequency spectrum, results in less space availability for additional systems to operate within the spectrum. Therefore, in reference to the military, SM practices should be given critical consideration in the development and operation of a variety of spectrum dependent military communications and satellite systems. Ultimately, failure to properly manage this can significantly impact the military's mission effectiveness.

Spectrum Management Contributions to the Acquisition Life Cycle Framework

Although, SM contributions to the DoD acquisition life cycle appear less visible than the contributions and requirements of other functional disciplines as outlined in DoDI 5000.02, it certainly remains a vital ingredient to the success of the entire mission accomplishment. As with other Systems Engineering Disciplines (SEDs), SM contributions can be clearly represented within the phases of acquisition. Figure 11 outlines the activities and products that must be developed with regards to the acquisition life cycle framework. This graphical representation provides the SM POC with a bird's eye view of how SM integrates within the acquisition life cycle framework. It also illustrates the required SM support for pre and post contract award acquisition activities as well as across the system lifecycle.

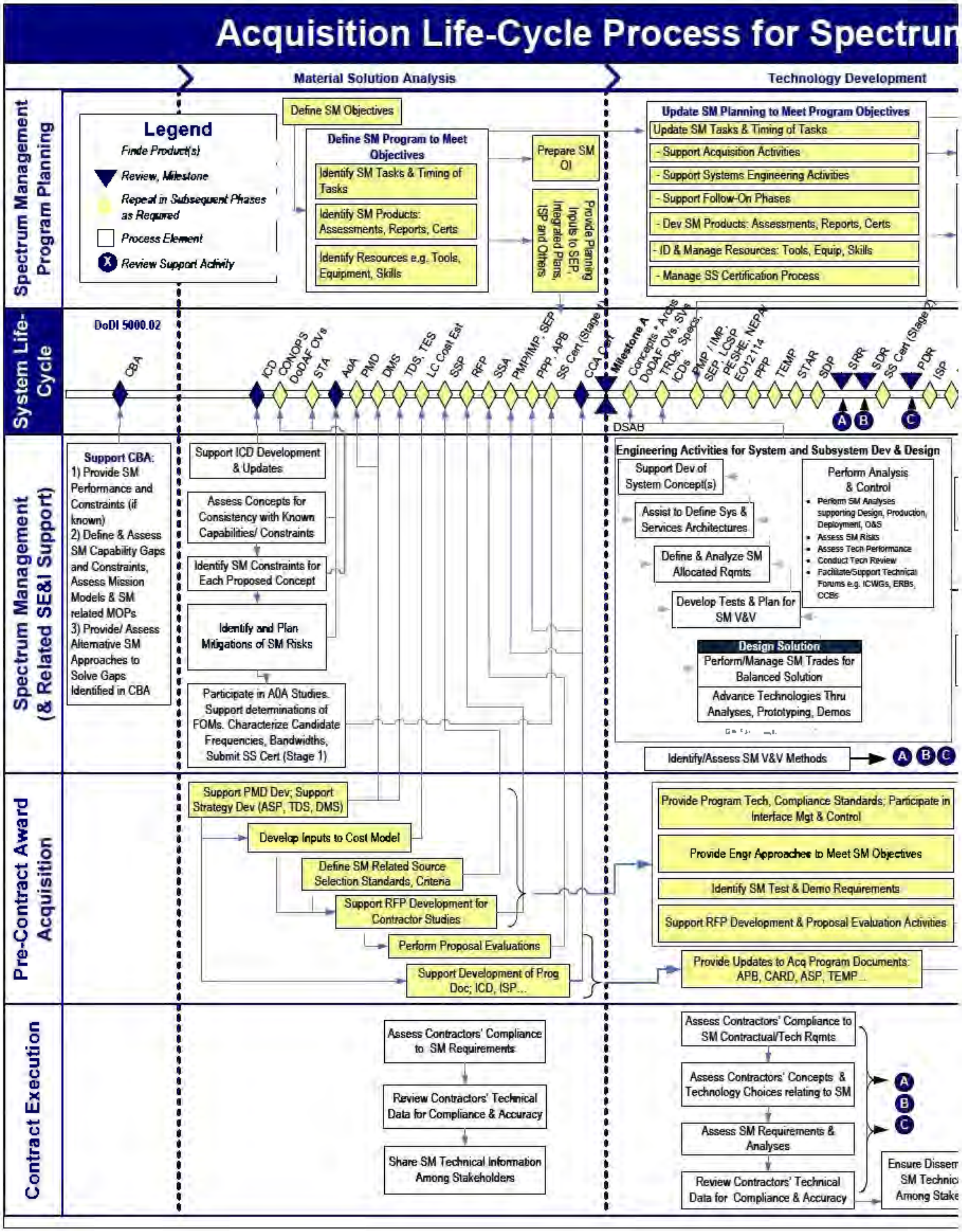
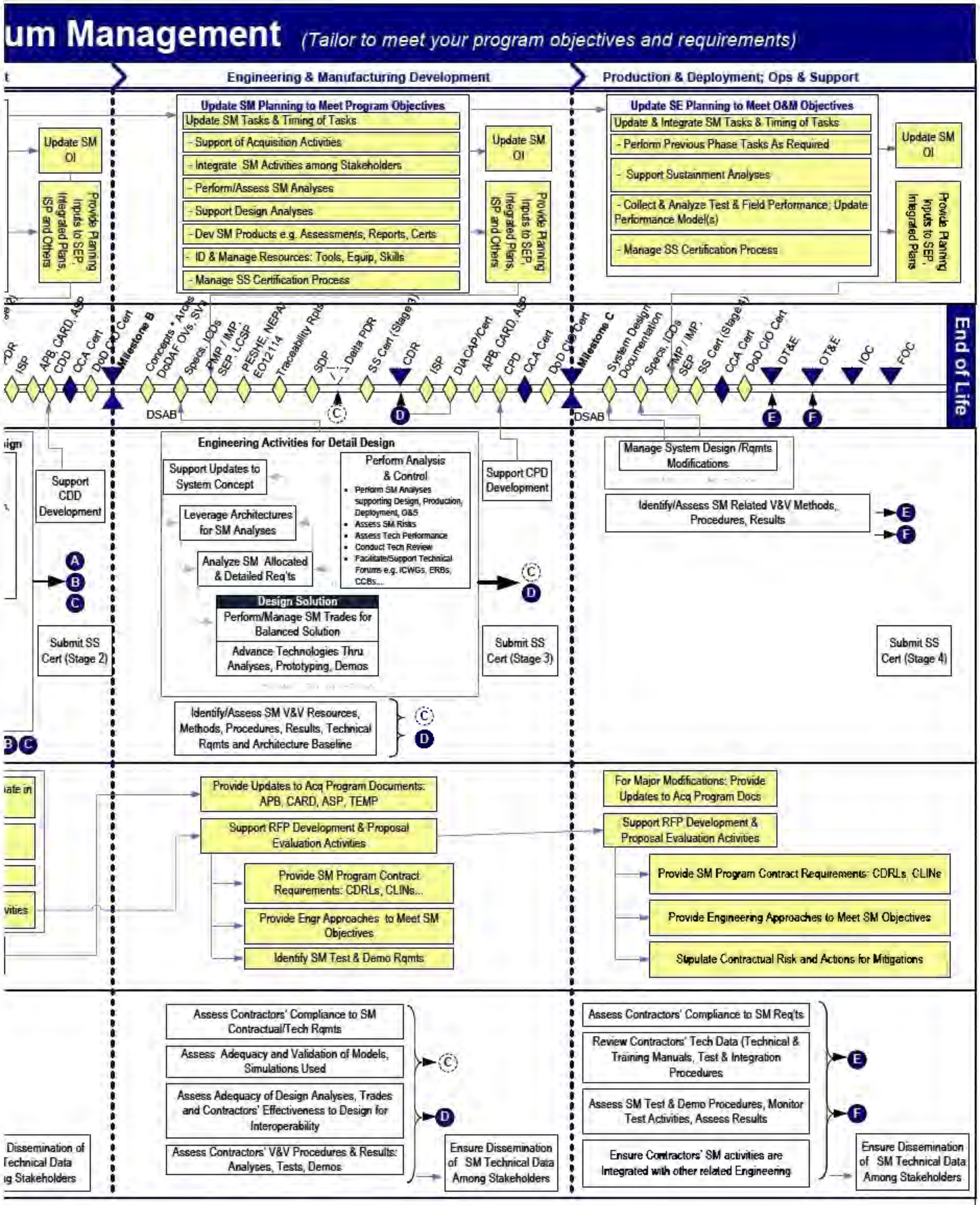


Figure 11 Acquisition life cycle process for SMC Spectrum Management


um Management (Tailor to meet your program objectives and requirements)
Engineering & Manufacturing Development
Production & Deployment; Ops & Support
Update SM Planning to Meet Program Objectives
Update SM Tasks & Timing of Tasks
- Support of Acquisition Activities
- Integrate SM Activities among Stakeholders
- Perform/Assess SM Analyses
- Support Design Analyses
- Dev SM Products e.g. Assessments, Reports, Certs
- ID & Manage Resources: Tools, Equip, Skills
- Manage SS Certification Process
Update SM OI
Provide Planning Inputs to SEP, Integrated Plans, ISP and Others
Update SE Planning to Meet O&M Objectives
Update & Integrate SM Tasks & Timing of Tasks
- Perform Previous Phase Tasks As Required
- Support Sustainment Analyses
- Collect & Analyze Test & Field Performance; Update Performance Model(s)
- Manage SS Certification Process
End of Life
ISP
APB, CARD, ASP
CDD
CCA Cert
DoD CIO Cert
Milestone B
Concepts * Archs
DoDAF OVs, SVs
Specs, ICDs
PMP / IMP
SEP, LCSP
PESHE, NEPA/EO12114
Traceability Rqts
SDP
Delta PDR
SS Cert (Stage 3)
CDR
ISP
DIACAP/Cert
APB, CARD, ASP
CPD
CCA Cert
DoD CIO Cert
Milestone C
System Design Documentation
Specs, ICDs
PMP / IMP
SEP
SS Cert (Stage 4)
CCA Cert
DoD CIO Cert
DT&E
OT&E
IOC
FOC
DSAB
DSAB
Support CDD Development
Engineering Activities for Detail Design
Support Updates to System Concept
Leverage Architectures for SM Analyses
Analyze SM Allocated & Detailed Req'ts
Perform Analysis & Control
Perform SM Analyses supporting Design, Production, Deployment, O&S
Assess SM Risks
Assess Tech Performance
Conduct Tech Review
Facilitate/Support Technical Forums e.g. ICWGs, ERBs, CCBs...
Design Solution
Perform/Manage SM Trades for Balanced Solution
Advance Technologies Thru Analyses, Prototyping, Demos
Support CPD Development
Submit SS Cert (Stage 2)
Submit SS Cert (Stage 3)
Submit SS Cert (Stage 4)
Identify/Assess SM V&V Resources, Methods, Procedures, Results, Technical Rqmts and Architecture Baseline
Manage System Design /Rqmts Modifications
Identify/Assess SM Related V&V Methods, Procedures, Results
Provide Updates to Acq Program Documents: APB, CARD, ASP, TEMP
Support RFP Development & Proposal Evaluation Activities
Provide SM Program Contract Requirements: CDRLs, CLINs...
Provide Engr Approaches to Meet SM Objectives
Identify SM Test & Demo Rqmts
For Major Modifications: Provide Updates to Acq Program Docs
Support RFP Development & Proposal Evaluation Activities
Provide SM Program Contract Requirements: CDRLs, CLINs
Provide Engineering Approaches to Meet SM Objectives
Stipulate Contractual Risk and Actions for Mitigations
Assess Contractors' Compliance to SM Contractual/Tech Rqmts
Assess Adequacy and Validation of Models, Simulations Used
Assess Adequacy of Design Analyses, Trades and Contractors' Effectiveness to Design for Interoperability
Assess Contractors' V&V Procedures & Results: Analyses, Tests, Demos
Ensure Dissemination of SM Technical Data Among Stakeholders
Assess Contractors' Compliance to SM Req'ts
Review Contractors' Tech Data (Technical & Training Manuals, Test & Integration Procedures
Assess SM Test & Demo Procedures, Monitor Test Activities, Assess Results
Ensure Contractors' SM activities are Integrated with other related Engineering
Ensure Dissemination of SM Technical Data Among Stakeholders

An effective SM program is instituted in the early phases of the acquisition life cycle and anticipates challenges and obstacles to overcome. As part of the pre-acquisition process, SM must be included in the Capabilities Based Assessment (CBA), taking into account the entire system lifecycle for a spectrum dependent system. Considerations must be given to the availability of the particular electromagnetic spectrum throughout the life span of the system, spectrum supportability, as well as the Electromagnetic Environmental Effects (E3), which addresses the electromagnetic environment's impact on the military operational capability, equipment, subsystems, systems and platforms.

According to Office of Management and Budget (OMB) Circular A-11, submission of funding estimates for the development or procurement of systems or equipment can only be conducted after obtaining spectrum support. In addition, spectrum certification is also a pre-requisite to obligating funds for spectrum-dependent equipment or systems. Below are the SM activities that are highlighted in the respective phases of the Acquisition lifecycle.

1. **Materiel Solution Analysis.** During this phase the SMC SM office completes and submits inputs to the program acquisition process in the form of an initial Stage 1 (Conceptual) request for a Spectrum Supportability Certification (DD Form 1494) for approval. The DD Form 1494 provides data pertaining to frequency assignments, including coordination with Host Nations (HN), mitigation/resolution of EMI issues, as well as integration of Commercial Items (CI) into military platforms and installations to name a few . By submitting the Stage 1 DD Form 1494, the SM is indicating that initial planning has been complete, including proposed frequency bands and other available characteristics. In addition, the SM office shall also provide insight to E3 and Spectrum Supportability (SS) functionality in the ICD to address operational capabilities, gaps or shortcomings with respect to spectrum usage, access, or support areas. The table to the right exhibits the products that are produced during the Materiel Solution Analysis phase.

MSA Phase – SMC Acquisition Products
DD Form 1494
ASP, TDS, DMS, TES
LC Cost Estimate Inputs
RFP inputs (SM requirements; Safety assessment requirements; High level SM assessments of concepts
APB, CCA
SEP, LCMP Inputs

2. **Technology Development.** In this phase of the acquisition life cycle, The SM prepares and facilitates the attainment of a Stage 2 SS Certification prior to authorization to perform experimental testing. A Stage 2 SS Certification request indicates that the preliminary design has been completed and on-air radiations, using test equipment or preliminary models may be required. It must also indicate specific sites, geographic locations and coordinates of the equipment to be used. The SM initiates requests for HN authorization for the use of spectrum dependent equipment in the respective countries. The table to the right displays the requisite documentation that is generated during the TD Phase as it relates to SM.

TD Phase – SMC Acquisition Products
DD Form 1494
Updates to ASP, TDS, DMS
CDD inputs
TEMP detailed planning
RFP, SOW, PWS, CDRLs
LC Cost Estimate Update / CARD Development
RFP: SM objectives in the SOO; SM related tasks in SOW, SM data products in CDRLs
Detailed SM planning, SEP, LCMP, TEMP

The SM also supports the solicitation/RFP development and proposal evaluation activities. The SM provides spectrum engineering and management technical inputs including requirements, compliance standards, engineering approaches relating to SM.

3. **Engineering & Manufacturing Development.** The next phase of the acquisition lifecycle capitalizes on the efforts produced in the previous phases. As in the previous phases, DoD Instruction 5000.02 mandates that a SS Certification (Stage 3) is provided prior to authorization to operate for developmental testing. Stage 3 certification denotes that the major design has been completed and radiation may be required, and specifies the geographic location of the system.

EMD Phase – SMC Acquisition Products
DD Form 1494
Updates to ASP, TDS, DMS
CARD update/ Inputs
RFP: SM objectives in the SOO; SM related tasks in SOW, SM data products in CDRLs
Detailed SM planning, SEP, LCMP, TEMP updates

4. **Production & Deployment, Operations & Support.** In the PD and O&S phases, the role that SM plays is much less prominent than in earlier stages of the acquisition lifecycle. This is attributable to the fact that much of the SM effort is aimed at producing the best possible solution at an early onset of the acquisition process in order to mitigate potential electromagnetic spectrum conflicts between various equipment and agencies along the acquisition timeline. In the PD phase, the final SS Certification (Stage 4) is required prior to authorization to conduct operational testing of a spectrum dependent system. Obtaining Stage 4 SS Certification essentially indicates development has been completed and final operating constraints required for compatibility need to be identified. The SM ensures that measured data for all technical characteristics such as emission bandwidth, harmonic level, spurious levels, etc is provided upon submission for a Stage 4 frequency allocation application. The geographic location of the system's operations must also be as specific as possible.

P&D / O&S Phase – SMC Acquisition Products
DD Form 1494
Stage 4 Note-to-Holders
Updates to ASP, TDS, DMS
CARD update/ Inputs
RFP: SM objectives in the SOO; SM related tasks in SOW, SM data products in CDRLs
Detailed SM planning, SEP, LCMP, TEMP updates

Generally, the SM requirements are in place by the time the system reaches the OS phase as this is often driven by financial and budgeting requirements. However, minor changes to an existing frequency allocation in lieu of a new allocation, are permitted in post Stage 4 certification via the ESC process through the use of a mechanism noted as "Note-to-Holders."

SM Contributions to the Engineering Life Cycle Framework

Relationship to SE Organization

The SM plans and executes the essential spectrum management and engineering efforts in an integrated and effective manner within the context and full support of the overarching Systems Engineering (SE) function. SM ensures that each SM SED contribution is timely, adequate, consistent, and compliant. The SM ensures that their contributions are channeled through the Systems Engineering *Analyses and Control* activity.

SM contributes and integrates with the Systems Engineering process and activities as depicted in Figure3. The SM is an integral team member in participating in the development/derivation of requirements and support for the requirements analyses and allocations process to derive the SM related set of requirements.

Strong participation in the early pre-acquisition periods is a requirement for the SM Manager/Engineer. The SM must work closely with the System Engineers in performing interface analyses, as well as the integration, verification and validation planning and execution. In performing the management and control function, the Systems Engineer effectively integrates all engineering functions through the full system life cycle. The SM

Engineer ensures that technical information, as related to SM advances, is appropriately applied through systematic control, collaboration and sharing across the organization.

In order to successfully integrate SM into the acquisition lifecycle phases, the SM is required to actively participate in the various reviews throughout the lifecycle. This is to ensure that the program's technical baseline is sufficient to support the program's cost estimates and acceptable levels of risk. These reviews are identified in each of the following acquisition phases along with the various Systems Engineering technical products and other contributions for further clarification.

Relationship to other SEDs

SM SED's relationship to other SEDs is summarized in Figure 1. The PM may also assign the SM the responsibility to facilitate development of the space-to-ground, ground-to-ground wireless links. If so, the SM engineering efforts will likely be closely aligned to the signal / antenna engineers to characterize, define, and design the space-to-ground, ground-to-ground links and associated system elements. The SM also supports T&E to ensure eventual testing to verify / validate SM related requirements.

Tools Selection & Use

The SM considers effectiveness and efficiencies gained by selecting and using the best choice of SM tools.

SM Functions Requiring Tools
Spectrum analyses
Multi-use frequency management
Spectrum planning
Spectrum supportability risk assessments

Engineering Activities and Products over the Life Cycle

The following subsections summarize the SM Engineer's contributions to engineering activities and technical products by DoD acquisition phase.

1. **Materiel Solution Analysis.** During this phase the SM may provide inputs to and support the Capabilities Based Assessment process and the JCIDS process. The Program Office SM may support the development of the mission and operational concepts, support AoA studies, support determinations of FOMs, and characterize candidate frequencies, bandwidths, and provide/assess technology solutions. The SM also contributes to the development of the MSA Phase technical products.

MSA Phase – Technical Products Required	
SMC Spectrum Management Technical Products	**SM Contributions to Other Organizations**
High level assessment proposed concepts & architectures	Operational Concepts
SM engineering inputs and factors for concept, architecture, technology studies and trades	AoA Studies
SM Requirements	Initial Capabilities Doc (ICD) Development

2. **Technology Development.** During this phase the SM continues to provide inputs to and supports the JCIDS process and activities to include inputs to the CDD. Concurrently, E3 and SS requirements are also required to be addressed in this phase. SM supports updates to include these requirements in the Capability Development Document (CDD). The CDD typically addresses spectrum requirements that cover safety issues related to electromagnetic energy radiation/reception, any potential issues regarding E3 interference from threat emitters, as well as interoperability issues. It also provides a forum of discussions on E3 and SS including interoperability matters involving Net Ready-Key Performance Parameters (NR-KPP) as it relates to E3, SS and Host Nation Authorizations.

TD Phase – Technical Products Required	
SMC Spectrum Management Technical Products	**SM Contributions to Other Organizations**
Updates to SM requirements	CDD
Inputs to System Concepts	Operational Concepts
Factors for Studies/Trades	Operational Assessments

The SM provides E3 and SS requirements inputs to the Information Support Plan (ISP) and system technical requirements documents. The ISP must address SS to include Equipment Spectrum Certification (ESC), reasonable assurance of the availability of operational frequencies, and consideration of E3 control in accordance with DoD Instruction 3222.3. The goal is to identify implementation issues such as E3 and SS support needs, dependencies, and interfaces that pertain to net-readiness, interoperability and information supportability, and information sufficiency concerns.

The SM also supports the engineering activities highlighted within the box titled *Engineering Activities for System & Segment Development & Design* Figure 11 to commence system definition and development. The SM contributes to support development of technology and transition roadmaps, architectural and other system trades. The SM assesses adequacy of contractor spectrum analyses. The SM assists to define or update the operational Electromagnetic Environment (EME). The table to the right displays the requisite documentation that is generated during the TD Phase as it relates to SM.

The SM also addresses E3/SS testing requirements (which is to be included in the TEMP), updates to the operational Electromagnetic Environment (EME), preparation and submission of the Stage 3 DD Form 1494 request, refinement of cost estimates for all E3/SS tasks and related activities, and obtainment of SS approval for MS B.

3. **Engineering & Manufacturing Development.** The SM continues to provide inputs to and support the JCIDS process. The SM supports the development of the Capability Production Document (CPD). The CPD, like the ICD and the CDD, must address both E3 and SS, including the electromagnetic environment in which the system is being designed to operate in as well as interfacing systems. It readdresses the NR-KPP requirements and refines the detailed picture of the spectrum integration requirements covering safety issues related to electromagnetic energy radiation/reception, any potential issues regarding E3 interference from threat emitters, as well as interoperability issues.

EMD Phase – Technical Products Required	
SMC Spectrum Management Technical Products	**SM Contributions to Other Organizations**
Updates to SM requirements	CPD
Updates to System Concepts	Operational Concepts
Technical Studies/Trades	Operational Assessments
Test, Demo Reports	

In addition, the SM provides inputs to the ISP. Similar to the TD phase, the ISP must address SS to include Equipment Spectrum Certification (ESC), reasonable assurance of the availability of operational frequencies, and consideration of E3 control. The SM supports the engineering activities highlighted within the box titled *Engineering Activities for Detailed Design* Figure 11 to commence detailed systems definition and development. The SM contributes to development of architectural and other system trades and engineering analyses. The SM also contributes to the development of the EMD Phase technical products. The SM provides inputs to T&E to ensure the TEMP is updated to reflect any changes to E3 and SS metrics, such as the Measures of Effectiveness (MOEs) and Measures of Suitability (MOSs) established in the TD phase. The SM also considers any E3 that is a critical operational effectiveness and suitability parameter and provides an updated schedule for E3 verification events and responsibilities.

4. **Production & Deployment, Operations & Support.** The SM continues to provide inputs to and supports the JCIDS process. The SM supports OT&E as directed by the SE Lead to ensure SM related requirements met.

P&D / O&S Phase – Technical Products Required	
SMC Spectrum Management Technical Products	**SM Contributions to Other Organizations**
Inputs tech baseline engineering changes	Supportability assessment contribution report
Test, Demo Reports	Operational assessments contributions

Spectrum Management Engineers' Contributions to Program and Project Management

The SMC Program Office defines their business model and approach structure based primarily on their program objectives, program and technical challenges, organizational structure, as well as program and engineering planning (SEP plus detailed engineering planning).

The SM develops and implements the essential detailed planning to achieve SM related engineering and program objectives and requirements. The planning defines the SM tasks and functions to be performed and products to be developed; timing of tasks, task outputs, resources (skills, tools, equipment, and completion criteria. The SM plans tasks to integrate SM activities across the program office, between Contractors and stakeholders. The SM plans the tasks to establish and manage SM activities and forums; support SE&I activities and Specialty Engineering activities; and integrate SM planning with other program and acquisition plans (i.e. SEP, IMP, ASP, LCMP).

Execution of the SM planning is typically defined through the Systems Engineering Operating Instruction (OI). The SM assists to establish the business model, develop program planning and schedules, and define and implement program processes. The SM ensures the SM components of the program are appropriately represented in the program plans, program schedules, work breakdown schedules, cost estimates. The SM also reports their technical performance and progress to engineering and program management. The SM shares in the risk management responsibilities to identify, assess, and propose mitigating actions of SM related risks. They also support the Program Manager's problem identification, resolution, and decision making processes. With regards to risk, the procurement of spectrum dependent systems requires the application of risk management tools to help identify shortfalls and potential future problems without committing a large amount of effort and resources. The Spectrum Supportability Risk Assessment (SSRA) is a tool that contributes toward successful Program/Project management with respect to the SM discipline. The SSRA is used to provide risk assessments that increase in detail as the spectrum dependent system design matures. It assists in identifying regulatory, operational and technical SS risks, and affords the program/project manager opportunities to mitigate and deconflict potentially disastrous SS issues. This tool is utilized throughout the acquisition, engineering and management lifecycle and is integrated into the ISP.

The table in this section identifies the program management products that the SM office contributes toward developing.

SMC Program Management Products
PMD, IMP, IMS, WBS
Technical progression and issues
LC Cost Estimate
Processes (Operating Instructions)
Risk Management Inputs (SSRA)

Appendix I – Concept Development

Generally, concept development begins with the development of the joint operating concepts, joint functional concepts, and joint integrating concepts that are developed by the operating or using commands. Representatives from impacted DoD communities examine multiple concepts to optimize the way the Department of Defense provides the intended capabilities. The analyses results of the concepts then contribute to the initial development of the ICD. A system concept development effort is then initiated once a capability shortfall or an emerging or evolving change to a military threat has been identified and it has been determined that a new or revised system is required.

This SED highlights XR's tasks and products and further delineates the Program Office tasks and products in support of the development of the operational and system concepts. Instructions, guidance, and senior experts are available at SMC/XR to assist the Program Office to execute the essential concept development activities for the Program Office.

Typically, the Program Office supports XR in the efforts to initially develop system concept alternatives then determine and document the preferred system concept. As a system concept matures, and is determined to be the preferred concept, the XR developmental planning efforts may be transitioned to the Program Office to be further advanced in technical fidelity and evolve with the program ensuring that the required capability meets the military need. A proper concept development effort facilitates subsequent program phases that define, produce and deliver materiel solutions within an identified trade-space in support of capability needs analyses.

Developing a concept for a new or improved system requires the application and rigor of the systems engineering process that responds to a new or evolving operational needs or deficiencies. While a top down flow of activities appears in a typical concept development cycle, in reality the concept development is more often than not an iterative process with multiple iterations and influences from many participants. These include Operators, Maintainers, Technologists, Engineers, and the Acquisition Community participation. While system concept development is often performed or led by a systems engineer, it is usually accomplished by a team that can be characterized as "A Community of Interest". For the purpose of this document, we will call this individual or team the *Concept Developer*.

The Concept Developer plans and performs the essential engineering conceptual development and management efforts to ensure that the resulting program is timely, adequate, consistent, and compliant with the military need.

Applicable governance, standards, and guidance

Policy, directives, and instructions that mandate concept development related program requirements are included in a wide range of mandates. Table 14 below identifies the significant governance, standards, and guidance which generally require SMC compliance for concept development.

DOD Instruction 5000.02 requires the joint operating concepts, joint functional concepts, and the concept of operations be initiated prior to the Materiel Solution Analysis phase. The preferred system concept is then determined during the Technology Demonstration. In general, a Milestone B is planned when a system concept has been selected.

AFSPC Instruction 10-102 provides clarification for a space system's system-level CONOPS as the enabling concept defined as a high-level written description of a space system that identifies the system's purpose, operational assumptions, the desired effects, how the system will be used, and who is envisioned to operate and use it.

Table 14 Governance, standards, and guidance that shape the Concept Development discipline

Document No	Governance Title	Issue
DoDI 5000.02	Operation of the Defense Acquisition System	08 Dec 08
CJCSI 3010.02B	Joint Operations Concepts Development Process (JOpsC-DP)	27 Jan 06
CJCSI 3170.01G	Joint Capabilities Integration and Development System	01 Mar 09
AFI 10-601	Operational Capability Requirements Development	12 Jul 10
AFI 10-604	Capabilities-Based Planning.	10 May 06
AFI 10-2801	Air Force Concept Of Operations Development	24 Oct 05
AFI 63-101	Acquisition and Sustainment Life Cycle Management	22 Mar 11
AFI 63-1201	Life Cycle Systems Engineering	23 Jul 07
AFI 99-103	Capabilities Based Test And Evaluation	6 Aug 04
AFSPCI 10-102	Concept Development	15 Nov 08
AFSPCI 61-101	Space Science And Technology (S&T) Management	18 Oct 07
Document No	**Standards Title**	**Issue**
SMC-S-001	Systems Engineering Requirements & Products	12 July 10
Document No	**Guidance Title**	**Issue**
	Joint Operations Concepts Development Process (JOPSC-DP) Pocket Guide	9 Jan 08
DoDAF 2.0	Department of Defense Architecture Framework 2.0 Volumes, 1, 2, 3	28 May 09
DAU DAG	Defense Acquisition Guidebook	05 May 10
DISR	https://www.disronline.disa.mil	
SMC-G-001	Systems Engineering Implementation Guide	17 Apr 09
	FY08 Space Technical Planning Integrated Product Team (TPIPT) Concept Data Collection Guide (Interim)	
	SMC / XR Concept Development Guide (Interim)	

Concept Development Contributions to the Acquisition Life Cycle

The DoD acquisition life cycle is defined by DoDI 5000.02. Concept Development contributions over this life cycle are best represented within the phases of the Defense Acquisition Management System. Figure 12 provides the acquisition life cycle framework within which the Concept Developer performs as well as the products that the Concept Developer must develop or contribute to their development.

The Concept Developer defines and implements concept development strategies and objectives consistent within the tenets of applicable policies, SMC acquisition objectives and requirements, and program objectives, requirements, and constraints. The Concept Developer assists the operating organizations to develop, attain approval for, and implement operational concepts into a CONOP and capability documents as they fit into the acquisition cycle, e.g. Initial Capability Document (ICD), Capability Development Document (CDD), and Capability Production Document (CPD). This planning will be firmly based on program and technical objectives, strategies, DOD mandates, and instructions.

The need to develop space concepts may originate from any AFSPC Directorate, NAF, and Wing, the Air Staff or a unified commander. Command Leads are (or SMC Leadership is) responsible for developing concepts that fall within their relevant core capability area. The planning defines concept development activities and products to achieve the overall program objectives and requirements; specifies tasks and functions to be performed, timing of tasks, resources required, products to be developed forms the basis for the Space Technical Planning Integrated Product Teams (TPIPTs) Concepts. For early concept development, the concept development planning is executed per the SMC / XR Concept Development Guide that documents the process to perform, control, and integrate concept development and management activities. When the preferred system concept is determined and approved, the concept development efforts are transferred from XR to the Program Office where the emphasis is refinement of the system concept(s).

The Program Office concept planning is based on the appropriate program-approved life cycle. SMC Program Offices define and implement the system concept development strategies and objectives consistent within the tenets of appropriate policies, SMC acquisition objectives, and program objectives. At SMC, the Program Office Concept Developer supports the major acquisition activities through the full system life cycle to ensure concept development and program requirements are fully extended through SMC specific programs and their developments.

1. **Pre-Materiel Solution Analysis.** During this phase, SMC/XR is typically the key SMC player in supporting the Capability Based Assessment (CBA) development though the Program Office Concept Developer may also support the CBA. SMC/XR and/or the Program Office Concept Developer will use the results of the CBA and any accompanying enabling concepts to propose potential solutions to identified capability needs and apply them to SMC Development Plans. Development plans which are vetted through concept assessment teams are provided as inputs to the ICD and AoA Study Plan. Concept development is integrated into the JROC's deliberations on identifying, developing, validating, and prioritizing requirements.

Pre-MSA Phase – SMC Acquisition Products
Inputs to joint operating, joint functional, & joint integrating concepts
Inputs to CBA
Inputs to Draft ICD
Inputs to AoA Study Plan

2. **Materiel Solution Analysis.** During this phase the Concept Developer provides inputs to and supports program acquisition activities to include the development of the acquisition strategy, technology demonstration, test strategies, inputs to the cost estimates, solicitation/RFP development for Contractor studies, and proposal evaluation activities. The Concept Developer also contributes to the development of the MSA Phase acquisition products. In addition, the Concept Developer verifies concept component functionality against desired capabilities. The XR leads or supports the system alternative concept analyses, concept models, and acquisition planning needed to fully develop a concept to where it can be transitioned to a SPO. The Concept Developer also contributes to the development of the acquisition MSA Phase products.

MSA Phase – SMC Acquisition Products
Inputs to AoA, ICD
TDS, DMS
LC Cost Estimate
RFP inputs: System Concepts, Ref Architectures
SEP

3. **Technology Development.** During this phase, the Concept Developer works closely with the Systems Engineers and Architecture Engineers, to analyze, trade, refine, and validate system concepts against the already defined user needs. The Concept Developer provides inputs to and supports program acquisition activities to include the acquisition strategy, technology development strategy, cost model, and solicitation/RFP development and proposal evaluation activities. The Concept Developer along with the Architecture Engineer establishes the functional and the physical architecture thereby assisting Systems Engineering to define the allocated baseline (preliminary design) with additional emphasis on maturing technologies with a TRL6 before milestone B approval.

TD Phase – SMC Acquisition Products
Updates to ASP, TDS, DMS
System Cost Model, LC Cost Estimate Update / CARD Development
RFP: System Concepts, Ref Architectures; Concept & Architecture objectives in the SOO; Concept development related tasks in PWS, Concept data requirements products in CDRLs; Data Item Description - tailored
ISP: operational concept
Inputs to CDD: Concepts of operation, description of the needed capability, operational risk
APB: Concept descriptions
Concept planning; Inputs to SEP, LCMP, TEMP, ISP

4. **Engineering & Manufacturing Development.** The Concept Developer provides inputs to and supports program acquisition activities to include updates to the acquisition strategy and updates to the cost model to reflect any change of technical solutions determined and updates to the CARD. Inputs are also provided to identify system design constraints determined through concept analyses and refine system design requirements as a result of the iterative engineering analyses and developmental tests. The Concept Developer supports the solicitation/RFP preparation and operational concept development documented in the CPD to meet program objectives The Concept Developer ensures that the matured concept meet user capability needs and is consistent and in alignment with the contractual requirements. The Concept Developer contributes to the development and updates to the acquisition products identified in the table. One of the main objectives is to attain TRL7 or above for milestone C approval.

EMD Phase – SMC Acquisition Products
Updates to ASP, TDS, DMS
Inputs for CARD update
RFP: Concept & Architecture objectives in the SOO; Concept development related tasks in PWS, Concept data requirements products in CDRLs; Data Item Description - tailored
ISP: System operations concept
CPD inputs
APB: Concept descriptions
Concept development planning; inputs to SEP, LCMP, TEMP, ISP

5. **Production & Deployment, Operations & Support.** The Concept Developer provides inputs to and supports program acquisition activities to include updates to the acquisition strategy and to the cost model to reflect the actual technical solutions. The Concept Developer also ensures proper implementation of inputs previously provided to reduce integration and manufacturing risk and critical supportability aspects focusing on minimizing the logistics footprint. The concept development team supports post implementation review which compares actual system performance to program expectations and mission realities based upon the operational environment and CONOPS.

P&D / O&S – SMC Acquisition Products
Updates to ASP, TDS, DMS
CARD update
RFP: Concept development related tasks in PWS, Concept data requirements products in CDRLs; Data Item Description - tailored
Final ISP
Concept development/validation planning, SEP, LCMP, TEMP updates

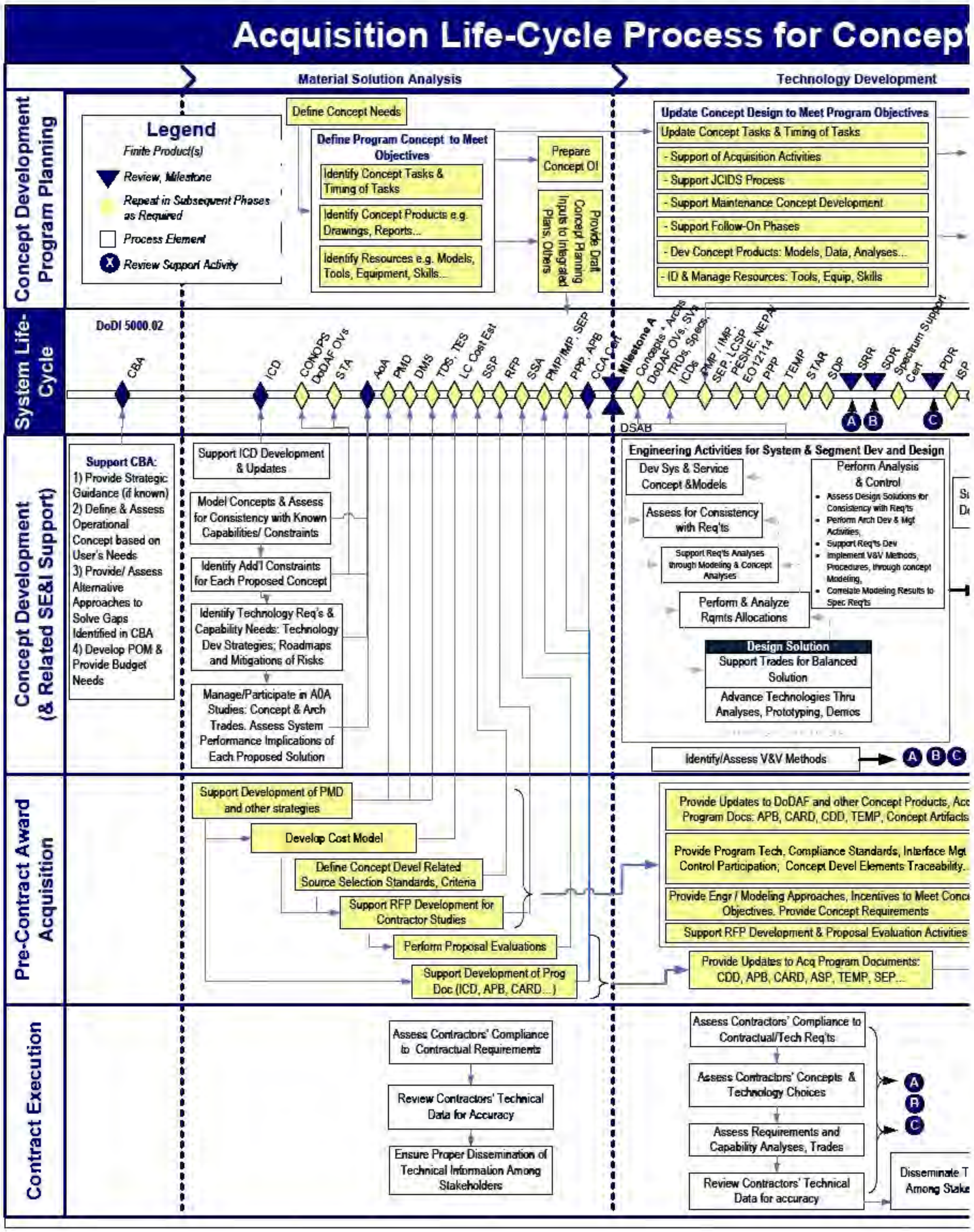
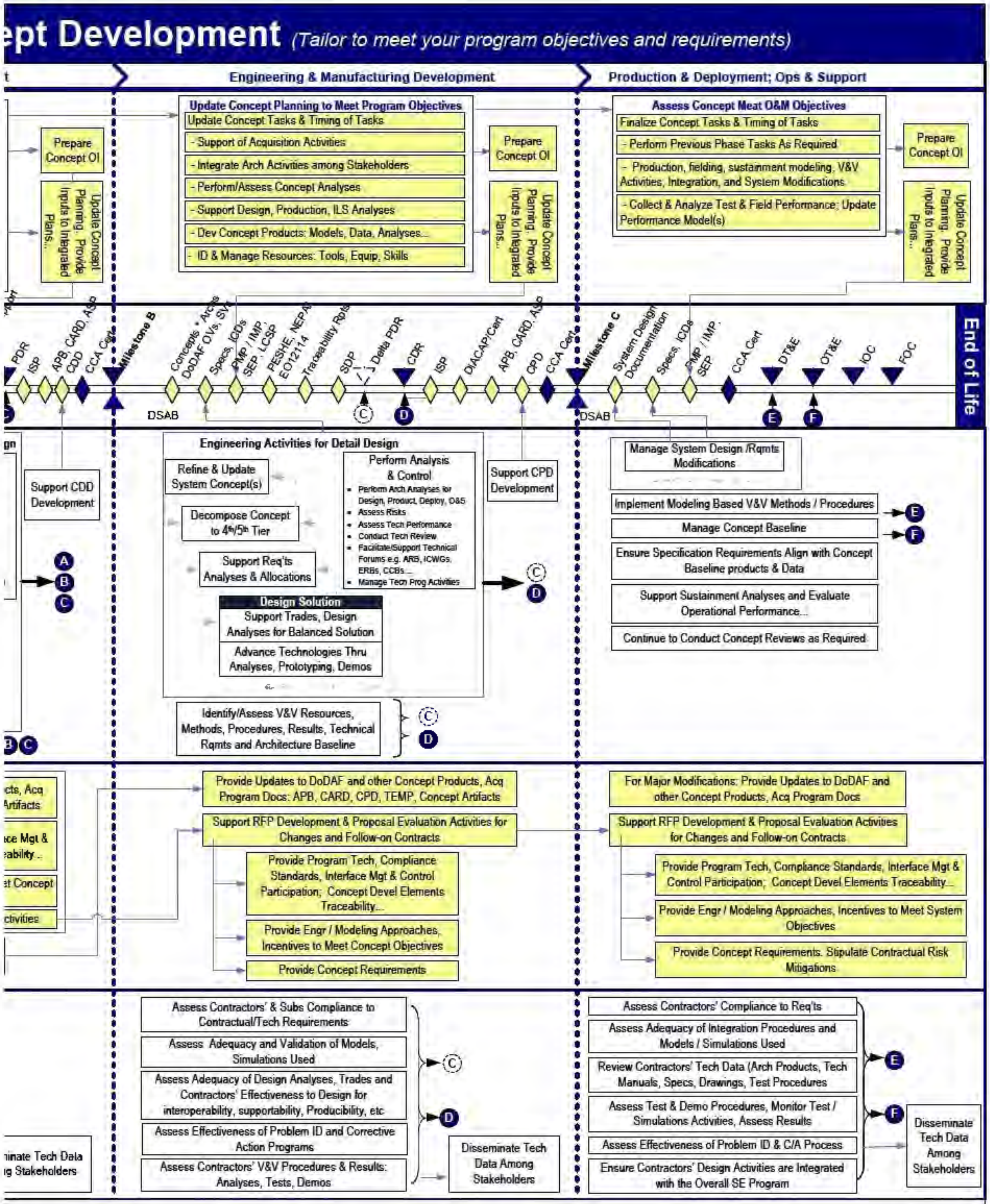


Figure 12 Acquisition life cycle process for SMC Concept Development


ept Development (Tailor to meet your program objectives and requirements)
Engineering & Manufacturing Development
Production & Deployment; Ops & Support
Update Concept Planning to Meet Program Objectives
Update Concept Tasks & Timing of Tasks
- Support of Acquisition Activities
- Integrate Arch Activities among Stakeholders
- Perform/Assess Concept Analyses
- Support Design, Production, ILS Analyses
- Dev Concept Products: Models, Data, Analyses...
- ID & Manage Resources: Tools, Equip, Skills
Prepare Concept OI
Update Concept Planning, Provide Inputs to Integrated Plans...
Assess Concept Meet O&M Objectives
Finalize Concept Tasks & Timing of Tasks
- Perform Previous Phase Tasks As Required
- Production, fielding, sustainment modeling, V&V Activities, Integration, and System Modifications
- Collect & Analyze Test & Field Performance; Update Performance Model(s)
End of Life
PDR
ISP
APB, CARD, ASP
CDD
CCA Cert
Milestone B
DSAB
Concepts + Arch
DoDAF OVs, SVs
Specs, ICDs
PMP / IMP
SEP, LCSP
PESHE, NEPA
EO12114
Traceability Rpts
SDP
Delta PDR
CDR
ISP
DIACAP/Cert
APB, CARD, ASP
CPD
CCA Cert
Milestone C
DSAB
System Design Documentation
Specs, ICDs
PMP / IMP
SEP
CCA Cert
DT&E
OT&E
IOC
FOC
Support CDD Development
Engineering Activities for Detail Design
Refine & Update System Concept(s)
Decompose Concept to 4th/5th Tier
Support Req'ts Analyses & Allocations
Perform Analysis & Control
Perform Arch Analyses for Design, Product, Deploy, O&S
Assess Risks
Assess Tech Performance
Conduct Tech Review
Facilitate/Support Technical Forums e.g. ARB, ICWGs, ERBs, CCBs...
Manage Tech Prog Activities
Design Solution
Support Trades, Design Analyses for Balanced Solution
Advance Technologies Thru Analyses, Prototyping, Demos
Support CPD Development
Identify/Assess V&V Resources, Methods, Procedures, Results, Technical Rqmts and Architecture Baseline
Manage System Design /Rqmts Modifications
Implement Modeling Based V&V Methods / Procedures
Manage Concept Baseline
Ensure Specification Requirements Align with Concept Baseline products & Data
Support Sustainment Analyses and Evaluate Operational Performance...
Continue to Conduct Concept Reviews as Required
cts, Acq Artifacts
ce Mgt & ability...
et Concept
ctivities
Provide Updates to DoDAF and other Concept Products, Acq Program Docs: APB, CARD, CPD, TEMP, Concept Artifacts
Support RFP Development & Proposal Evaluation Activities for Changes and Follow-on Contracts
Provide Program Tech, Compliance Standards, Interface Mgt & Control Participation; Concept Devel Elements Traceability...
Provide Engr / Modeling Approaches, Incentives to Meet Concept Objectives
Provide Concept Requirements
For Major Modifications: Provide Updates to DoDAF and other Concept Products, Acq Program Docs
Support RFP Development & Proposal Evaluation Activities for Changes and Follow-on Contracts
Provide Program Tech, Compliance Standards, Interface Mgt & Control Participation; Concept Devel Elements Traceability...
Provide Engr / Modeling Approaches, Incentives to Meet System Objectives
Provide Concept Requirements. Stipulate Contractual Risk Mitigations
Assess Contractors' & Subs Compliance to Contractual/Tech Requirements
Assess Adequacy and Validation of Models, Simulations Used
Assess Adequacy of Design Analyses, Trades and Contractors' Effectiveness to Design for interoperability, supportability, Producibility, etc
Assess Effectiveness of Problem ID and Corrective Action Programs
Assess Contractors' V&V Procedures & Results: Analyses, Tests, Demos
Disseminate Tech Data Among Stakeholders
inate Tech Data g Stakeholders
Assess Contractors' Compliance to Req'ts
Assess Adequacy of Integration Procedures and Models / Simulations Used
Review Contractors' Tech Data (Arch Products, Tech Manuals, Specs, Drawings, Test Procedures
Assess Test & Demo Procedures, Monitor Test / Simulations Activities, Assess Results
Assess Effectiveness of Problem ID & C/A Process
Ensure Contractors' Design Activities are Integrated with the Overall SE Program
Disseminate Tech Data Among Stakeholders

Concept Development Contributions to the Engineering Life Cycle

Relationship to the SE Organization

The Concept Developer plans and executes the essential concept development and management efforts in an integrated and effective manner within the context of system engineering. Other participants that support the concept development function may include implementers, integrators, other specialty engineers, and representatives of the eventual using organizations. The Concept Developer ensures that each of the SED contributions is timely, adequate, consistent, and compliant. The Concept Developer ensures that their contributions are channeled through the Systems Engineering *Analyses and Control* activity.

Systems Engineers manage the engineering process and activities depicted in Figure 3 while the Concept Developer contributes to this process by performing, managing, and supporting the concept development effort through the use of modeling and simulation, analyses; concept/architectural/design trades; and technology studies. The Concept Developer contributes to the Systems Engineering process and supports technical and program management activities by supporting decision making.

Relationship to other SEDs

The Concept Developer SED's relationship to other SEDs is summarized in Figure 1. The Program Office Concept Developer is likely most closely aligned with the Architecture Engineer or Team and the System Engineer to provide and trade on plausible system technical solutions. Specifically, the Concept Developer supports concept and architecture development and analyses; modeling and simulation efforts; technology studies; and design trades as well as supporting technical and program management activities and decision making. The Concept Developer supports the Architecture Engineer to assist in the requirements development activities and requirements analyses by creating dynamic system models, abstractions of a particular domain concept, or models to define system functions then allocate and parameterize requirements to perform the function.

The Concept Developer along with the Architecture Engineer supports the system trades taking into account all applicable factors to ensure balanced and integrated architecture solutions. The Concept Developer works closely with the Logistics Specialists to incorporate their deployment and sustainment concepts to reduce integration, deployment, and manufacturing risk and critical supportability aspects focusing on minimizing the logistics footprint.

Tools Selection and Use

The Concept Development team considers effectiveness and efficiencies gained by selecting and using the best choice of Modeling and Simulations tools to perform modeling and simulation analyses, information sharing, automated data exchanges with other tools, and other considerations.

Concept Development Functions Requiring Tools
Architectural Development
Modeling & Simulations
Technology Trade Studies and Data Analysis
Operational Concept Analysis

Engineering Activities and Products over the Life Cycle

SMC/XR leverages the results of the Capability Based Assessment (CBA) and any accompanying enabling concept and supporting analyses to propose potential solutions to identified capability needs and apply them to the product center Development Plans. SMC/ XR also manages the Program Executive Officer (PEO) / Technology Executive Officer (TEO) and Space Technology Integration Council (STIC) process to produce developmental plans for high-priority, near-, mid- and far-term concepts for inclusion in the Science and Technology Guidance Document. As concepts approach the mid to far term it starts becoming inappropriate to try to cost the concept as systems in acquisition can usually be estimated to a factor of 2 to 3. As more new technologies are needed cost estimates start becoming appropriate to only an order of magnitude. For far term concepts needing a lot of new technologies the XR Concept Developer appropriately specifies the cost a system should meet rather than specifically what it will cost. In the far term cost targets become a goal and the system design and technology needs specified to meet these goals.

The transition of concept development activities from XR to the Program Office vary from program to program. In most cases, the Program Office Concept Developer initiates a broader system and program concept development perspective while further enabling and maturing concepts. Similar to the XR Concept Developer, the Program Office Concept Developer continues to participate in technical trades to transform warfighter needs into technical solutions, identify needed technologies, generate developmental roadmaps, and mature technologies, and deliver materiel and operations solutions to operators.

The Concept Developer also ensures that the system concept evolves and is appropriately captured in the system design considering program objectives, requirements, and constraints and balancing conceptual solutions with a wide range of engineering factors to include those of safety, reliability, human systems integration, security, supportability, environmental, and of course cost.

For software developments by applying use case techniques, the Concept Developer can assist the engineering team capture system behavioral requirements by detailing scenario-driven threads through functional requirements. By creating other functional and dynamic system models, abstractions of a particular domain concept, and/or models, the Concept Developer assists the Systems Engineers in defining system functions, parameterizing requirements and providing functional and physical decomposition of design trades and interface definitions.

The Concept Developer plans and executes the essential concept development and management efforts to ensure that each concept contribution is timely, adequate, consistent, and compliant. The Concept Developer ensures contributions are channeled through the Systems Engineering activities so that system evolution decisions are properly vetted and documented.

The following subsections summarize the Concept Developer contributions to engineering activities and technical products by DoD acquisition phase.

1. **Pre-Materiel Solution Analysis.** SMC/XR is a key player in the Capability Based Assessment (CBA) development though the Program Office Concept Developer may also support the CBA. During this phase, SMC/XR is typically the key SMC player in supporting the Capability Based Assessment (CBA) development SMC/XR and/or the Program Office Concept Developer will use the results of the CBA and any accompanying enabling concepts to propose potential solutions to identified capability needs and apply them to SMC Development Plans. Development plans which are vetted through concept assessment teams are provided as inputs to the ICD and AoA Study Plan. Concept development is integrated into the JROC's deliberations on identifying, developing, validating, and prioritizing requirements. The Program Office Concept Developer leads or supports XR in the efforts to develop system concept alternatives then determine and document the preferred system concept

Pre-MSA Phase – Technical Products Required	
SMC Concept Development Technical Products	**Concept Devel Contributions to Other Organizations' Products**
System Architecture Req'ts (draft	Inputs to CBA
High level performance and sustainment analyses	Inputs to AoA Studies , Technology Roadmap
Architecture inputs and factors for concept, architecture, technology studies, and trades	Inputs to Operational Concepts

2. **Materiel Solution Analysis.** During this phase the Concept Developer may provide inputs to and support the Capabilities Based Assessment process and the JCIDS process. The Concept Developer contributes to the development of the mission and operational concept models and provides assistance to architecture artifacts. The Concept Developer also contributes to the development of the MSA Phase technical products ensuring to minimize complexity both within the system and with regards to the system external interfaces.

MSA Phase – Technical Products Required	
SMC Concept Development Technical Products	**Concept Devel Contributions to Other Organizations' Products**
High level performance and sustainment analyses	Inputs to CBA, ICD
Architecture inputs and factors for concept, architecture, technology studies, and trades; CVs, OVs	Inputs to AoA Studies , Technology Roadmap
Enabling Concepts	Inputs to Operational Concepts

3. **Technology Development.** During this phase the Concept Developer main focus is to demonstrate and validate system concept processes in order to ensure delivery of integrated, matured technologies. The Concept developer continues to provide inputs to and supports the JCIDS process and activities. The Concept Developer also supports the concept development activities highlighted within the box titled *Engineering Activities for System & Segment Development & Design* Figure 12 to commence system definition and development. The Concept Developer contributes to development of technology roadmaps, avoiding use of high risk, immature technologies, and system trades and analyses. The Concept Developer contributes to the development of TD Phase technical products with emphasis on enabling and critical technologies.

TD Phase – Technical Products Required	
SMC Concept Development Technical Products	**Concept Devel Contributions to Other Organizations' Products**
Inputs for performance and sustainment analyses	Inputs to CBA, CDD
Architecture inputs and factors for concept, architecture, technology studies, and trades; CVs, OVs, SVs, SvcVs, StdVs, AVs,	Inputs to AoA Studies , Technology Roadmap
Enabling/System Concepts	Inputs to Operational Concepts & Assessments
Factors for Studies/ Trades	

4. **Engineering & Manufacturing Development.** At this stage, the Concept Developer contributes to reducing integration and manufacturing risk, and design-in critical supportability aspects. The Concept Developer continues to provide inputs to and support the JCIDS process. The Concept Developer supports the concept development activities highlighted within the box titled *Engineering Activities for Detailed Design* Figure 12 to commence detailed systems definition and development. The Concept Developer contributes to development of technology roadmaps and system trades and analyses. The Concept Developer also contributes to the development of the EMD Phase technical products and completion of the technical baseline to include baseline concept development products and data. The Concept Developer supports prototyping, prototype testing, modeling and simulation, DT&E as directed by the Systems Engineering Lead to ensure interoperability, system integration, supportability, safety, utility and other requirements assigned to the concept development to meet system operational capability.

EMD Phase – Technical Products Required	
SMC Concept Development Technical Products	**Concept Devel Contributions to Other Organizations' Products**
Inputs for performance and sustainment analyses	Inputs to CBA, CPD
Architecture inputs and factors for concept, architecture, technology studies, and trades; ISP; CVs, OVs, SVs, SvcVs, StdVs, AVs,	Inputs to AoA Studies , Technology Roadmap
Evolving System Concept(s)	Inputs to Operational Concepts & Assessments
Factors for Studies/ Trades	
Inputs to system, production, fielding, sustain design docs	

5. **Production & Deployment, Operations & Support.** The Concept Developer continues to provide inputs to and supports the JCIDS process. The Concept Developer ensures the actual system performance to program expectations and mission realities based upon the operational environment and CONOPS are met.

P&D / O&S Phase – Technical Products Required	
SMC Concept Development Technical Products	**Concept Devel Contributions to Other Organizations' Products**
Operational Assessments	Supportability Analyses Rpt
Operational Concepts and Models	Inputs tech baseline engineering changes
System Concepts	Inputs to Transition & Fielding Docs

Concept Development Contributions to Program and Project Management

Each Concept Developer defines their conceptual model approach and planning based primarily on the required operational capabilities and objectives, conceptual designs and technical challenges, such as technology maturation and any demonstrated deficiencies. The Concept Developer supports program management activities and program level management decisions, by contributing to the risk management process, providing cost models for cost estimating and budget planning, assisting and developing technology roadmaps to define future states of a system, e.g., To-Be and Objective states, operational-need solutions, mission-need solutions, and to evolve systems to achieved pre-planned incremental capabilities.

The Concept Developer develops and implements the concept development program planning to achieve the required objectives and requirements. The planning defines the concept development tasks and functions to be performed; products to be developed; and timing of tasks, task outputs, resources (skills, tools, equipment, and completion criteria). The Concept Developer plans tasks to integrate concept development activities within the Program Office, between contractors, and community stakeholders. The Concept Developer plans the tasks to establish and manage operations and system concepts, support SE&I activities, e.g., system technical solutions trades and analyses risk management, integration, and system modifications; coordinate the concept development planning with Systems Engineering, operating commands, supporting commands, and test agencies; and integrate the planning with other functional and acquisition plans (i.e. SEP, ASP, LCMP).

Execution of the concept development planning is typically defined through an Operating Instruction (OI). The Concept Developer provides full support to define the program and technical objectives where concept and architectural challenges and risks are known or anticipated. The concept and architecture team assist in establishing the business model, developing program planning and schedules, and defining and implementing program processes. The Concept Developer ensures the concept development and management components of the program are appropriately represented in the program plans, program schedules, work breakdown schedules, and cost estimates. The Concept Developer reports their technical performance and progress. The Concept Developer shares in the risk management responsibilities to identify, assess, and propose mitigating actions of their related risks. Concept Developer also supports the program manager's problem identification, resolution, and decision-making processes.

Appendix J – Architecture Engineering

SMC Program Office Systems Engineering organization designates a POC (referred to in this SED as an Architecture Engineer) who implements the DoD and Air Force interoperability, IT, and acquisition mandates and engineering best practices requiring architectural contributions. Policies and mandates that affect SMC architecture commitments and architecture decisions are many. In the interoperability and information technologies categories, the mandates are partly driven by evolving DoD Net-Centric warfare (NCW) doctrine to radically improve information sharing by employing robust modern information technologies.

In addition, investments in front end systems modeling and analyses allows the Program Office to commence acquisitions with more complete system level requirements sets and sufficient or high fidelity requirements, functional, and physical allocations to support our acquisition strategic planning, technologies assessments, and prepare the technical components of a RFP. Through applying use case techniques, the Architecture Engineer assists the engineering team capture system behavioral requirements by detailing scenario-driven threads through functional requirements. By creating dynamic system models, abstractions of a particular domain concept, and/or models, the Architecture Engineer assists the Systems Engineers to define system functions, parameterize requirements to perform the functions, and provides functional and physical decomposition of design trades and interface definition and decisions. Systems modeling and analyses is a time-proven approach that reduces requirements creep, reduces costly engineering changes and keeps control of the development schedule by identifying and mitigating technical risks early. In addition, architecture products are essential to describe operational and system concepts, operational environments such as production, integration and sustainment, and mission scenarios.

The Architecture Engineer plans and executes the essential architecture development and management efforts in an integrated and effective manner to ensure that each Architecture SED contribution is timely, adequate, consistent, and compliant. The Architecture Engineer ensures that their contributions are channeled through the Systems Engineering *Analyses and Control* activity. The architecture team also supports engineering efforts, acquisition activities, and management activities and decision making.

Applicable governance, standards, and guidance

Policy, directives, and instructions that mandate architecture engineering related program requirements are included in a wide range of mandates. Table 15 below identifies the significant governance, standards, and guidance which generally require SMC compliance for architecture engineering.

Table 15 Governance, standards, and guidance that shape the Architecture Engineering discipline

Document No	Governance Title	Issue
	Net-centric Enterprise Solutions for Interoperability (NESI) Policy	08 Jun 05
DoDD 8000.01	Management of the DoD Information Enterprise	10 Feb 09
DoDD 4630.05	Interoperability and Supportability of Information Technology (IT) and National Security Systems (NSS)	23 Apr 07
DoDI 5000.02	Operation of the Defense Acquisition System	08 Dec 08
DoDI 4630. 8	Procedures for Interoperability and Supportability of Information Technology (IT) and National Security Systems (NSS)	30 Jun 04
CJCSI 3170.01G	Joint Capabilities Integration and Development System	01 Mar 09
CJCSI 6212.01E	Interoperability And Supportability Of Information Technology And National Security Systems	15 Dec 08

	Air Force Policy on Enterprise Architecting	06 Aug 02
AFI 33-124	Enterprise Information Technology Architectures	01 May 00
AFI 33-133	Joint Technical Architecture – Air Force	01 July 00
AFI 33-401	Air Force Information Technology Portfolio Management and IT Investment Review	14 Mar 07
AFPD 33-4	Enterprise Architecting	27 Jun 06
Document No	**Standards Title**	**Issue**
DI – MGMT- 81644A	DoD Architecture Framework Documentation	10 Nov 08
SMC-S-001	Systems Engineering Requirements & Products	12 July 10
Document No	**Guidance Title**	**Issue**
DoDAF 2.0	Department of Defense Architecture Framework 2.0 Volumes, 1, 2, 3	28 May 09
DAU DAG	Defense Acquisition Guidebook	05 May 10
	DoD Enterprise Architecture Federation Strategy Draft Version 1.01	04 Dec 06
DISR	https://www.disronline.disa.mil	
	FORCEnet Service Description Framework Version 2.0	30 Mar 07
	Federal Architecture Framework Documentation	
SMC-G-001	Systems Engineering Implementation Guide	17 Apr 09
SMC-G-XXX	Architecture Development & Management Guide (Interim)	24 Dec 09
UML	Unified Modeling Language at http://www.uml.org/	
SysML	Systems Modeling Language at http://www.sysml.org/	

Architecture Contributions to the Acquisition Life Cycle Framework

The DoD acquisition life cycle is defined by DoDI 5000.02. Architecture Engineering contributions over this life cycle are best represented within the phases of the Defense Acquisition Management System. Figure 14 provides the acquisition life cycle framework within which the Architecture Engineer performs as well as the products that the Architecture Engineer must develop or contribute to their development. This figure supports pre and post contract award acquisition activities, and performs integrated architecture management and engineering across the system lifecycle. The Program Office Architecture Engineer establishes and implements architecture program strategies and objectives consistent with the tenets of applicable policies, SMC acquisition objectives, and program objectives. The Architecture Engineer then develops, attains approval for, and implements architecture planning into the Systems Engineering Plan (SEP) and higher level integrated planning (e.g., IMP) in accordance with current DoD policy. This planning will be firmly based on program and technical objectives, strategies, DoD mandates, and instructions.

The Program Office Architecture Engineer supports all of the major acquisition activities through the full system life cycle to ensure architecture program requirements are fully extended to all contributing contractors through the appropriate contract SOO and work statement language, compliance standards, etc. Hence, the Architecture Engineer supports RFP development by providing PWS and SOO language, deliverable requirements (CDRLs, Data Item Descriptions) for architecture products and data, and contractual requirements to participate in forums that advance and approve the architecture artifacts. The Architecture Engineer prepares proposal evaluation criteria, assists to evaluate proposals and carries out contractor performance assessments during contract execution.

The planning sufficiently defines architecture activities and products to achieve the architecture and overall program objectives and requirements; specifies tasks and functions to be performed, timing of tasks, resources required, and products to be developed; forms the basis for the development of the Program Office Systems Engineering Operating Instruction (OI) architecture elements. The architecture planning and OI will be reflected appropriately in the WBS, IMS, and other program documents that address architecture related elements. The architecture planning is executed concurrently with the Program Office OI that documents the process to perform, control, and integrate all architecture engineering and management activities for each phase of acquisition. Program office architecture planning (usually contained in the SEP and the detailed architecture program planning) and OI will also be based upon the appropriate program-approved life cycle. SMC Program Offices appoint establish and implement Architecture program strategies and objectives consistent with the tenets of appropriate policies, SMC acquisition objectives, and program objectives.

1. **Materiel Solution Analysis.** During this phase, the Architecture Engineer provides inputs to and supports most program acquisition activities to include the development of the acquisition strategy, inputs to the cost estimates, solicitation/RFP development for Contractor studies, and proposal evaluation activities. The Architecture Engineer also contributes to the development of the acquisition MSA Phase products.

MSA Phase – SMC Acquisition Products
PMD
TDS, DMS, TES
LC Cost Estimate
RFP inputs (Concepts, OVs)
APB, CCA
SSP, SEP

2. **Technology Development.** The Architecture Engineer provides inputs to and supports all program acquisition activities to include the development of the acquisition strategy, technology development strategy, development and updates to the cost model and development of the Cost Analysis Requirements Description (CARD), solicitation/RFP development and proposal evaluation activities. The Architecture Engineer establishes the functional and the physical architecture thereby assisting Systems Engineering to define the allocated baseline.

TD Phase – SMC Acquisition Products
ASP
Updates to TDS, DMS
System Cost Model, LC Cost Estimate Update / CARD Development
RFP: Architecture objectives in the SOO; Architecture related tasks in SOW, Architecture task requirements products in CDRLs; SMC- Architecture Data Item Description - tailored
SSP: evaluation criteria for Architecture
APB: Arch objectives & related concept descriptions
Detailed Arch planning, SEP, LCMP, TEMP, ISP

3. **Engineering & Manufacturing Development.** The Architecture Engineer provides inputs to and supports all program acquisition activities to include updates to the acquisition strategy and updates to the cost model to reflect the actual technical solutions determined and updates to the CARD. The Architecture Engineer supports the solicitation/RFP development and proposal evaluation activities which include providing the technical inputs including technical requirements, compliance standards, and engineering approaches to meet program objectives. Architect contributes to the development and updates to the acquisition products identified.

EMD Phase – SMC Acquisition Products
Updates to ASP, TDS, DMS
CARD update
RFP: SOO architecture objectives; Sow architecture tasks, Architecture products in CDRLs; SMC-Architecture Data Item Description- tailored
SSP: evaluation criteria for architecture
APB: architecture objectives concept descriptions
Architecture planning, SEP, LCMP, TEMP, ISP

4. **Production & Deployment, Operations & Support.** The Architecture Engineer provides inputs to and supports all program acquisition activities to include updates to the acquisition strategy and updates to the cost model to reflect the actual technical solutions determined and updates to the CARD. The architecture team supports the solicitation/RFP development and proposal evaluation activities.

P&D / O&S Phase – SMC Acquisition Products
Updates to ASP, TDS, DMS
CARD update
RFP: Architecture objectives in the SOO; Architecture related tasks in SOW, Architecture task requirements products in CDRLs; SMC- Architecture Data Item Description- tailored
SSP: evaluation criteria for Architecture
Architecture planning, SEP, LCMP, TEMP updates

Architecture Contributions to the Engineering Life Cycle Framework

Relationship to the SE Organization

The Architecture Engineer plans and executes the essential architecture development and management efforts in an integrated and effective manner within the context and full support of the overarching Systems Engineering (SE) function. The Architecture Engineer ensures that each of their SED contributions is timely, adequate, consistent, and compliant. The Architecture Engineer ensures that their contributions are channeled through the Systems Engineering *Analyses and Control* activity.

Systems Engineers manage the engineering process and activities depicted in Figure 3 while the Architecture Engineer contributes to this process. Architecture engineers perform, manage, and support the concept and architecture development and analyses; modeling and simulation efforts; technology studies. The Architecture Engineer contributes to the Systems Engineering process. The Architecture Engineer supports concept and architecture development and analyses; modeling and simulations efforts; technology studies; decomposition of design trades; interface definition and decision; and integrated architecture solutions. As well as supporting technical and program management activities and decision making. The Architecture Engineer also supports requirements development activities and requirements analyses by creating dynamic system models, abstractions of a particular domain concept, or models to define system functions then allocate and parameterize requirements to perform the function.

The Architecture Engineer supports the system trades taking into account all applicable factors to ensure balanced and integrated architecture solutions. The Program Office Architecture Engineer typically participates and supports the development of the capability viewpoints (CVs) and the operational viewpoints (OVs) developed by the operator and user organizations. They ensure the operating and using organizations are provided an opportunity to support the development of the systems viewpoints (SVs), services viewpoints (SvcVs), and standards viewpoints (StdVs). As the architectural artifacts are developed, the architecture team ensures that all related architecture elements (CV, OV, SV, SvcV) are fully mapped in a relational database, map to the applicable requirement sets, and a common lexicon of architecture elements are documented in all viewpoints (AV-2).

The architecture development process must be integral to the Systems Engineering process. The illustration below provides an executable architecture development process that inherently produces the architecture artifacts as an output of the Systems Engineering process, and to ensure the architecture products are then appropriately vetted and leveraged through the Systems Engineering organization and community of stakeholders.

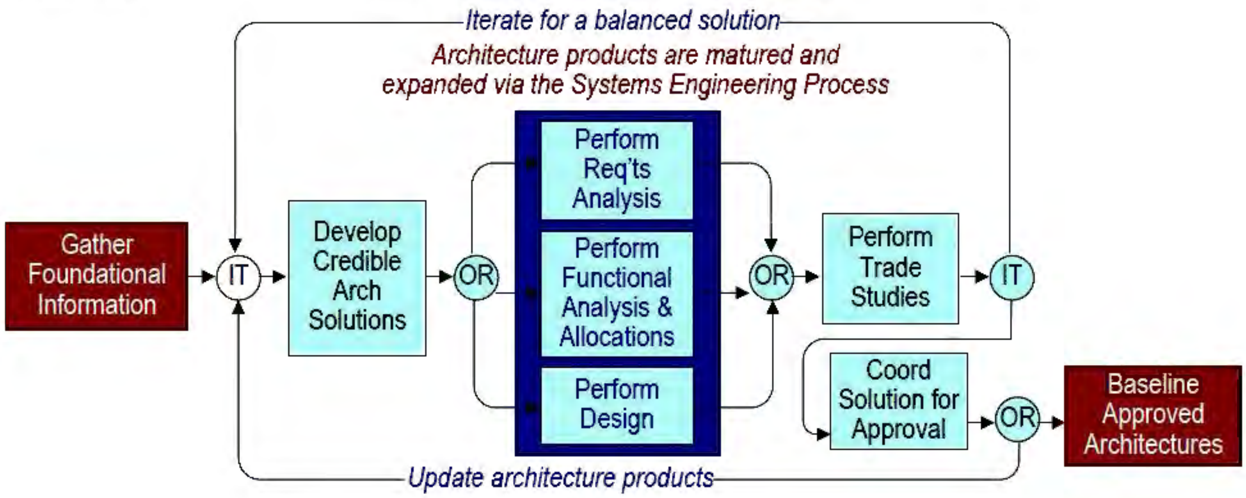


Figure 13 Architecture development executed within the Systems Engineering process

Relationship to other SEDs

The Architecture Engineer SED's relationship to other SEDs is summarized in Figure 1. The Architecture Engineers provide functional perspectives for reliability and safety to perform their failure and hazards analyses, Use case Diagrams to support the software engineers and Human Systems Integration activities, Physical perspectives to support development of reliability block diagrams and configuration specification trees.

The Architecture Engineer works with the Manufacturing Engineers to assess production and lay-outs; works with the Logistics Engineers to transform functional and activity diagrams to operations and field processing flows.

Tools Selection and Use

Architecture Functions Requiring Tools
Architecture Modeling
Requirements Analyses & Allocations
Design Trade Studies and Data Analysis
System Analysis

The architecture team considers effectiveness and efficiencies gained by selecting and using the best choice of architecture engineering tools considering the program office tools requirements to perform modeling, architectural and functional analyses, information sharing, automated data exchanges with other tools, and other considerations.

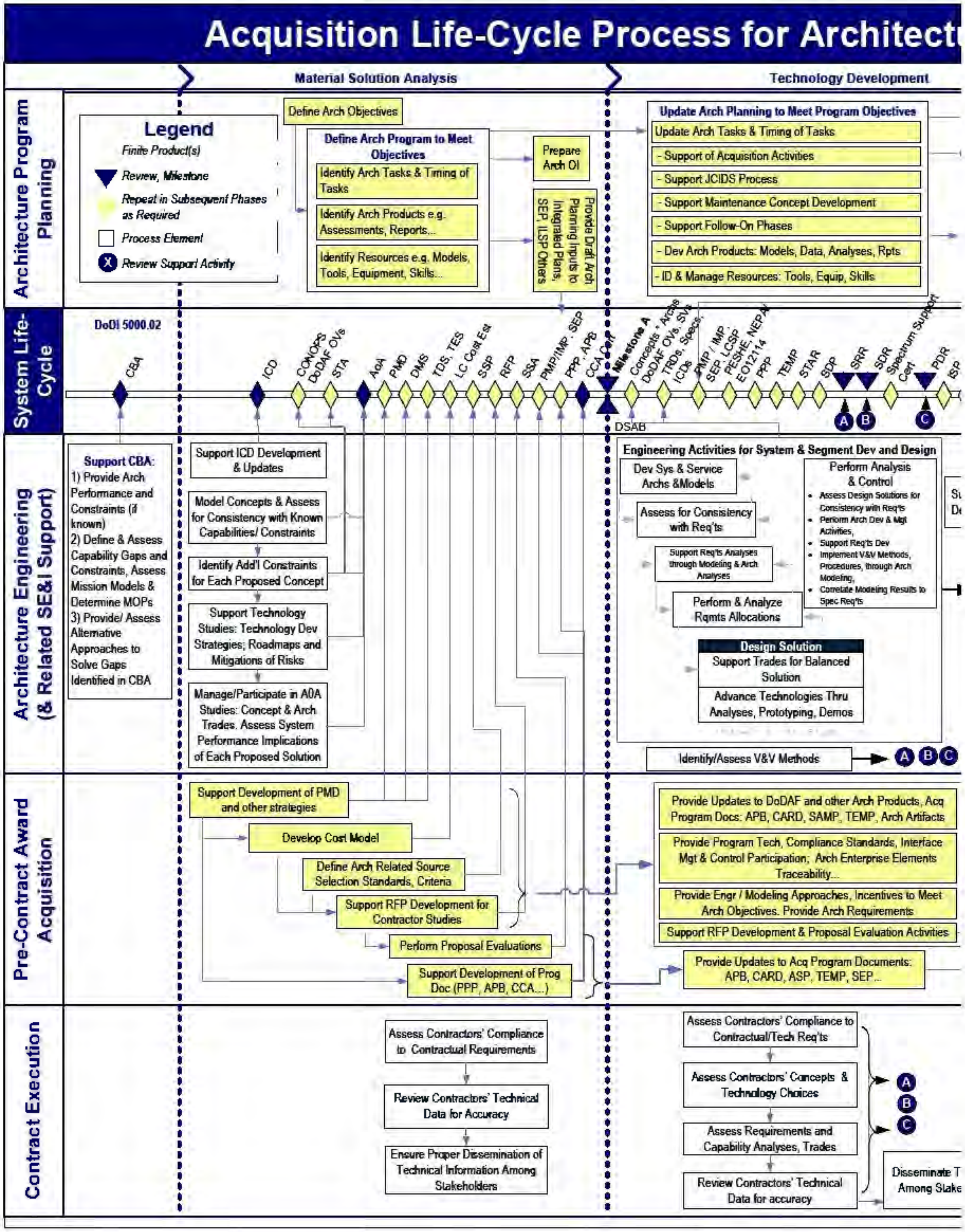
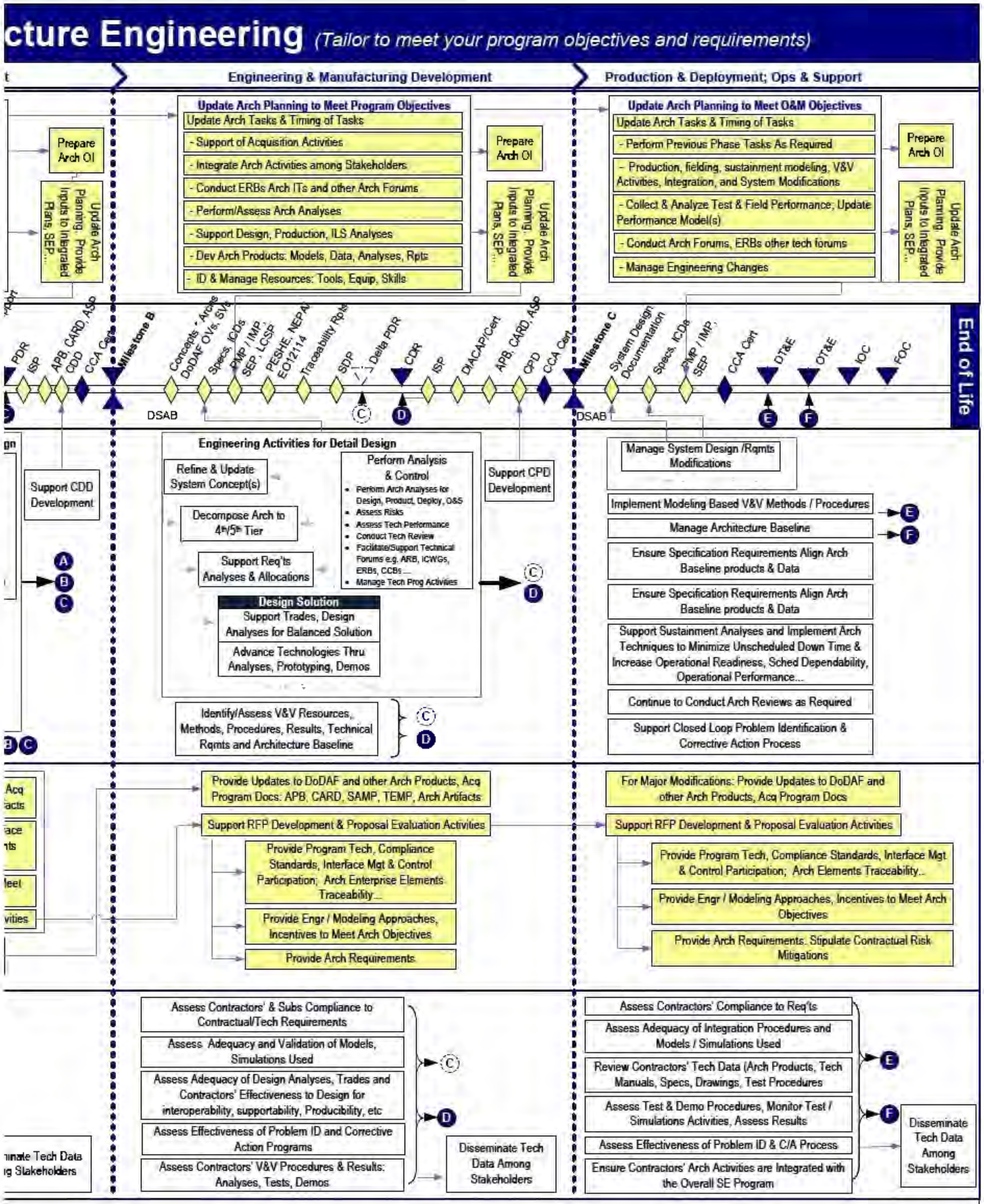


Figure 14 Acquisition life cycle process for SMC Architecture Engineering


cture Engineering (Tailor to meet your program objectives and requirements)
Engineering & Manufacturing Development
Production & Deployment; Ops & Support
Update Arch Planning to Meet Program Objectives
Update Arch Tasks & Timing of Tasks
- Support of Acquisition Activities
- Integrate Arch Activities among Stakeholders
- Conduct ERBs Arch ITs and other Arch Forums
- Perform/Assess Arch Analyses
- Support Design, Production, ILS Analyses
- Dev Arch Products: Models, Data, Analyses, Rpts
- ID & Manage Resources: Tools, Equip, Skills
Prepare Arch OI
Update Arch Planning, Provide Inputs to Integrated Plans, SEP...
Update Arch Planning to Meet O&M Objectives
Update Arch Tasks & Timing of Tasks
- Perform Previous Phase Tasks As Required
- Production, fielding, sustainment modeling, V&V Activities, Integration, and System Modifications
- Collect & Analyze Test & Field Performance; Update Performance Model(s)
- Conduct Arch Forums, ERBs other tech forums
- Manage Engineering Changes
End of Life
Milestone B
Milestone C
DSAB
Engineering Activities for Detail Design
Refine & Update System Concept(s)
Decompose Arch to 4th/5th Tier
Support Req'ts Analyses & Allocations
Perform Analysis & Control
Design Solution
Support Trades, Design Analyses for Balanced Solution
Advance Technologies Thru Analyses, Prototyping, Demos
Support CDD Development
Support CPD Development
Identify/Assess V&V Resources, Methods, Procedures, Results, Technical Rqmts and Architecture Baseline
Manage System Design /Rqmts Modifications
Implement Modeling Based V&V Methods / Procedures
Manage Architecture Baseline
Ensure Specification Requirements Align Arch Baseline products & Data
Support Sustainment Analyses and Implement Arch Techniques to Minimize Unscheduled Down Time & Increase Operational Readiness, Sched Dependability, Operational Performance...
Continue to Conduct Arch Reviews as Required
Support Closed Loop Problem Identification & Corrective Action Process
Provide Updates to DoDAF and other Arch Products, Acq Program Docs: APB, CARD, SAMP, TEMP, Arch Artifacts
Support RFP Development & Proposal Evaluation Activities
Provide Program Tech, Compliance Standards, Interface Mgt & Control Participation; Arch Enterprise Elements Traceability...
Provide Engr / Modeling Approaches, Incentives to Meet Arch Objectives
Provide Arch Requirements
For Major Modifications: Provide Updates to DoDAF and other Arch Products, Acq Program Docs
Provide Arch Requirements: Stipulate Contractual Risk Mitigations
Assess Contractors' & Subs Compliance to Contractual/Tech Requirements
Assess Adequacy and Validation of Models, Simulations Used
Assess Adequacy of Design Analyses, Trades and Contractors' Effectiveness to Design for interoperability, supportability, Producibility, etc
Assess Effectiveness of Problem ID and Corrective Action Programs
Assess Contractors' V&V Procedures & Results: Analyses, Tests, Demos
Disseminate Tech Data Among Stakeholders
Assess Contractors' Compliance to Req'ts
Assess Adequacy of Integration Procedures and Models / Simulations Used
Review Contractors' Tech Data (Arch Products, Tech Manuals, Specs, Drawings, Test Procedures
Assess Test & Demo Procedures, Monitor Test / Simulations Activities, Assess Results
Assess Effectiveness of Problem ID & C/A Process
Ensure Contractors' Arch Activities are Integrated with the Overall SE Program

Engineering Activities and Products over the Life Cycle

The following subsections summarize Architecture Engineer's contributions to engineering activities and technical products by DoD acquisition phase.

1. **Materiel Solution Analysis.** During this phase the Architecture Engineer may provide inputs to and support the Capabilities Based Assessment process and the JCIDS process. The Program Office Architecture Engineer contributes to the development of the mission and operational concept models and other architecture artifacts. The Architecture Engineer also contributes to the development of the MSA Phase technical products.

MSA Phase – Technical Products Required	
SMC Architecture Technical Products	**Contributions to Other Organizations' Products**
High level performance and sustainment analyses	Operational Concepts
Architecture inputs and factors for concept, architecture, technology studies, and trades	AoA Studies
System Architecture Req'ts (draft)	Initial Capabilities Doc (ICD) Dev
Roadmap inputs	DoDAF CVs, OVs

2. **Technology Development.** During this phase the Architecture Engineer continues to provide inputs to and supports the JCIDS process and activities. The Architecture Engineer also supports the engineering activities highlighted within the box titled *Engineering Activities for System & Segment Development & Design* Figure 14 to commence system definition and development. The Architecture Engineer contributes to development of technology and transition roadmaps, architectural and other system trades, and engineering analyses. The Architecture Engineer contributes to the development of TD Phase technical products.

TD Phase – Technical Products Required	
SMC Architecture Technical Products	**Contributions to Other Organizations' Products**
Inputs to System Concepts	Operational Concepts
Factors for Studies/ Trades	Operational Assessments
Architecture Tech Req'ts, TRD, SRD, Specifications, ICDs, Standards Selection/ Tailor	Capabilities Development Doc (CDD)
Architecture inputs to ISP	DoDAF CVs, OVs
SVs, SvcVs, StdVs, AVs,	
Architecture Analyses Rpts	

3. **Engineering & Manufacturing Development.** The Architecture Engineer continues to provide inputs to and support the JCIDS process. The Architecture Engineer supports the engineering activities highlighted within the box titled *Engineering Activities for Detailed Design* Figure 14 to commence detailed systems definition and development. The Architecture Engineer contributes to development of architectural and other system trades and engineering analyses. The Architecture Engineer also contributes to the development of the EMD Phase technical products and completion of the technical baseline to include all baselined architecture products and data. The Architecture Engineer supports

EMD Phase – Technical Products Required	
SMC Architecture Technical Products	**Contributions to Other Organizations' Products**
Update System Concept	Operational Concepts
Technical Studies/ Trades	Operational Assessments
System Tech Req'ts, TRD, SRD, Spec, ICDs; Architecture allocations	Capabilities Production Doc (CPD)
Inputs to system, production, fielding, sustain design docs	DoDAF CVs, OVs
SVs, SvcVs, StdVs, AVs,	
Architecture inputs to ISP	

prototype testing, qualification testing, DT&E as directed by the Systems Engineering Lead to ensure interoperability, integration and other requirements assigned to the architecture discipline are met.

4. **Production & Deployment, Operations & Support.** The Architecture Engineer continues to provide inputs to and supports the JCIDS process. The activities of the Architecture Engineer during this phase are extensive. The Architect maintains the baselined architecture products and data that are essential during the P&D / O&S Phases. The Architecture Engineer supports OT&E as directed by the SE Lead to ensure interoperability, integration and other requirements assigned to the architecture discipline are met.

P&D / O&S Phase – Technical Products Required	
SMC Architecture Technical Products	**Contributions to Other Organizations' Products**
Inputs tech baseline engineering changes	Supportability Analyses Rpt
Analyses of production quality reports and test reports	Operational Assessments
Inputs to Transition & Fielding Docs	
Architecture Models	
V&V / T&E Reports	

Architecture Contributions to Program and Project Management

Each program office defines their business model and business approach structure based primarily on their program objectives, program and technical challenges, organizational structure, as well as program and engineering planning. The Architecture Engineer supports the program management activities to support IPT and program level management decisions, to contribute to the risk management process, to provide cost models for cost estimating and budget planning, to assist and develop roadmaps to define future states of a system, e.g., To-Be, Objective States, and to evolve systems to achieved pre-planned incremental capabilities.

The Architecture Engineer develops and implements the Architecture program planning to achieve architecture objectives and requirements. The planning defines the architecture tasks and functions to be performed; products to be developed; and timing of tasks, task outputs, resources (skills, tools, equipment, and completion criteria). The Architecture Engineer plans tasks to integrate architecture activities within the program office, between contractors and community stakeholders. The Architecture Engineer plans the tasks to establish and manage operational architecture viewpoints, systems architecture viewpoints, support SE&I activities, e.g., system design, design and requirements traceability, V&V activities, risk management, internal and/or external interfaces, integration, and system modifications; coordinate the architecture planning with Systems Engineering, operating commands, supporting commands, and test agencies; and integrate architecture planning with other functional and acquisition plans (i.e. SEP, ASP, LCMP).

Execution of the architecture planning is typically defined through an Operating Instruction (OI). The Architecture Engineer provides full support to define the program and technical objectives where architectural challenges and risks are known or anticipated. The architecture team assists establishing the business model, developing program planning and schedules, and defining and implementing program processes. The Architecture Engineer ensures the architecture development and management components of the program are appropriately represented in the program plans, program schedules, work breakdown schedules, and cost estimates. The Architecture Engineer reports their technical performance and progress. The Architecture Engineer shares in the risk management responsibilities to identify, assess, and propose mitigating actions of their related risks. The Architecture Engineer also supports the program manager's problem identification, resolution, and decision-making processes.

Appendix K – System Safety Engineering

Systems Safety Engineering is a well-defined and established SMC discipline and it is one of the engineering disciplines inherent in the multi-disciplined Environment, Safety and Occupational Health (ESOH) subject area. Sufficient instructions, guidance, and senior expert SMC Staff resources are available to assist the Program Office System Safety Manager/Engineer (SSM) in establishing and executing a System Safety Engineering program. The SSM plans and executes the essential system safety engineering and management efforts in an integrated and effective manner to ensure that each system safety SED contribution is timely, adequate, consistent, and compliant. The SSM ensures that their engineering contributions are channeled through the Systems Engineering *Analyses and Control* activity.

Applicable governance, standards, and guidance

Policy, directives, and instructions that mandate SMC system safety engineering related program requirements are included in a wide range of mandates. Requirements are applied throughout program life cycle of all SMC acquisition programs and projects (existing and future SMC space systems) that involve design, development, modification, evaluation, demonstration, testing, operation and disposal.

DoDI 5000.02, AFI 63-101, AFI 63-1201, AFI 91-202_AFSPCSUP_I, AFI 91-217, and SMCI 63-1205 system safety related mandates for SMC acquisition programs include:

1. The Program Manager (PM) or Program Support Manager (PSM), Lead Systems Engineer / Chief Engineer, and System Safety Manager/Engineer (SSM) ensure that appropriate Human Systems Integration (HSI) and ESOH efforts are integrated across disciplines and into Systems Engineering to determine system design characteristics that can (1) minimize or eliminate the risks of system related mishaps; acute or chronic illness, disability, or death or injury to operators and maintainers; and (2) enhance job performance and productivity of the personnel who operate, maintain, or support the system.
2. The SSM ensures the T&E strategy addresses system safety in the development and assessment of the weapons support equipment during the EMD Phase, and into production, to ensure satisfactory safety of activities associated with test system measurement performance, calibration traceability and support, required diagnostics, and required system safety testing. The PM or PSM, in concert with the user and the T&E community, provides safety releases (to include formal Environment, Safety, and Occupational Health (ESOH) risk acceptance) to the developmental and operational testers prior to any test using personnel. During DT&E the development contractor must assess the safety of the system/item to ensure safety during Operational Test (OT) and other troop-supported testing and to support success in meeting design safety criteria.
3. The SSM supports the PM or PSM and Program HSI Engineer to take steps (e.g., contract deliverables and Government/contractor IPT teams) to ensure ergonomics, human factors engineering, and cognitive engineering is employed during Systems Engineering over the life of the program to provide for effective human-machine interfaces and to meet HSI requirements. Where practicable and cost effective, system designs shall minimize or eliminate system characteristics that require excessive cognitive, physical, or sensory skills; entail extensive training or workload-intensive tasks; result in mission-critical errors; or produce safety or health hazards.

4. The SSM ensures integration of ESOH risk management into the overall Systems Engineering process for all developmental and sustaining engineering activities. As part of risk reduction, the SSM supports the PM or PSM to eliminate ESOH hazards where possible, and manage ESOH risks where hazards cannot be eliminated. For SMC programs, the SSM uses the methodology in MIL-STD-882. The SSM reports on the status of ESOH risks to the PM or PSM who will report acceptance decisions at technical reviews. The PM or PSM ensures the acquisition program reviews and fielding decisions address the status of all high and serious risks, and applicable ESOH technology requirements. Prior to exposing people, equipment, or the environment to known system-related ESOH hazards, the SSM assists the PM or PSM to document that the associated risks have been accepted by the following acceptance authorities: the CAE for high risks, PEO-level for serious risks, and the PM or PSM for medium and low risks. The User representative shall be part of this process throughout the life cycle and shall provide formal concurrence prior to all serious- and high-risk acceptance decisions.
5. The PM or PSM, regardless of program ACAT level shall prepare a Programmatic Environment, Safety and Occupational Health Evaluation (PESHE) which incorporates the MIL-STD-882 process addressing (1) Identification of ESOH responsibilities, (2) Strategy for integrating ESOH considerations into the systems engineering process, (3) Identification of ESOH risks and their status, (4) Description of the method for tracking hazards throughout the life cycle of the system, and (5) Identification of hazardous materials, wastes, and pollutants associated with the system and plans for their minimization and/or safe disposal.
6. System Safety Management Plan (SSMP) and PESHE Schedules. The PESHE shall be developed to support milestone decisions (MS) with an initial submittal at MS-B and updated at MS-C and Full-Rate Production (or Full Deployment) Decision Review (DR). Adequate lead time will be considered when contracting out data deliverables required as data source for the PESHE. The PESHE document must be coordinated by SMC/SE and SMC/EN, signed by the Systems Director and approved by the appropriate management authority prior to the MS decision it supports. The SSMP and PESHE program schedules and activities will correspond and/or complement each other.
7. SSG, SSWG and PESHEWG. A System Safety Group (SSG) SSG must be established for all SMC acquisition programs and projects. It applies to Acquisition Category I (ACAT 1) or equivalent programs and to all SMC missile, launch vehicle, satellites and ground facilities unless waived by AFSPC/SES through SMC/SE. The SSG will be the method used by senior leadership to provide guidance and oversight to the SD's system safety program. The Systems Director, PM or PSM or the Deputy PM or PSM will chair the SSG. The SSG will be responsible for (1) evaluating the program System Safety status including funding, (2) ensuring all appropriate managers consider and document the residual risks of hazards, (3) reviewing the analyses of major safety design trade-offs and modifications. These analyses will include hazard risk descriptions, proposed corrective actions and their effect and current status, (4) reviewing the status of planned, pending, active, and disapproved safety modifications, (5) reviewing and possibly approving or disapproving selected hazard analysis and their recommended controls and verification, and (6) reviewing high accident potential reports.
    a. System Safety Working Group (SSWG). The SSWG will be established by the SSG to work detailed safety issues. The SSWG will be chaired by the SSM and typical activities include assessing the status of safety activities in the total system, various system segments, elements, subsystems and components. Hazards and their mitigations will be reviewed and disposed where ill-defined hazards will be returned to the originator for clarification and where valid hazards for

which mitigation proposals have not been made will be assigned to an action officer, for mitigation.

   b. Programmatic ESOH Evaluation (PESHE). Early in Pre-Systems Acquisition, the SSM will ensure that the charter for the PESHE Working Group (PESHEWG) will be drafted, coordinated, finalized and approved for implementation at the TD phase. The SSM will also ensure that appropriate membership and activities are cited in the PESHEWG charter. Typical membership includes organizational, environment and health representatives in addition to system safety. The SSM may also be tasked by the PM or PSM to write and oversee the coordination and completion of the PESHE document. The SSM is a key person in the establishment and activation of the PESHEWG.

8. Space Debris Assessment Report (SDAR) and End of Life Plan (EOLP). The SSM will ensure that required system safety related assessments and data submittals supporting operations and end-of-life actions are also included as contract data deliverables. These data include the Space Debris Assessment Report (SDAR) and End-of-Life Plan (EOLP). The SSM will also provide input to the contract to ensure the timely delivery of these data. For example, a PDR Draft SDAR is required 30 days before PDR and a CDR Draft SDAR is required 45 days before CDR.

9. Design and Disposal. Design and disposal plans shall be delineated in the SSMP. At the end of its useful life, a system will be demilitarized and disposed of in accordance with all legal and regulatory requirements and policy relating to safety (including explosives safety), security, and the environment. Disposal will take into consideration space debris and public safety risk minimization or elimination. During the design process, PMs or PSMs must document (in the PESHE) hazardous materials contained in the system and will estimate and plan for the system's demilitarization and safe disposal.

   a. End of Life Disposal. Programs shall develop appropriate disposal plans for orbital space systems to either to reenter the atmosphere safely or else be moved into a disposal orbit at the end of its useful where it will be less likely to interfere with operational spacecraft. Programs will provide an EOLP for the disposal of the space system at the end of its useful life. Effective disposal of nonfunctional space systems not only provides an immediate benefit by protecting operational spacecraft from accidental collisions with orbital debris, but also has the long-term benefit of reducing the probability of nonfunctioning objects colliding with one another and creating additional debris.

10. Mishap Investigation Support. PMs or PSMs shall support system-related Class A and B mishap investigations by providing analyses of hazards that contributed to the mishap and recommendations for materiel risk mitigation measures, including those that minimize human errors in accordance with AFI 91-204, "Safety Investigation and Reports," 24 September 2008 and AFI 91-222 AFSPC Supplement 2 January 2007, Space Safety Investigation and Reports." Once the Convening Authority accepts the Safety Investigation Board (SIB) or Single Investigator (SIO) final report that contains findings, recommendation, other findings of significance (OFS) and other recommendations of significance (ORS), the System Safety Manager will assist in implementing the recommendations and ORS to achieve closure conditions and closure dates. This will ensure prevention of future space mishaps.

11. Deficiency Reporting, Investigation, And Resolution. SSMs must be fully trained and qualified to effectively implement and participate in the USAF Deficiency Reporting and Investigating System (DRIS). This system promotes the ability to identify and correct deficiencies before they impact mission capability; thus, promoting Operational Safety, Suitability and Effectiveness (OSS&E).

Table 16 below identifies the significant governance, standards, and guidance which generally require SMC compliance for System Safety Engineering.

Table 16 Governance, standards, and guidance that shape the System Safety Engineering discipline

Document No	Governance Title	Issue
DoDI 5000.02	Operation of the Defense Acquisition System	08 Dec 08
CJCSM 3170.01	Operation of the Joint Capabilities Integration and Development System	24 Jun 03
DoDI 6055.1	DoD Safety and Occupational Health (SOH) Program	19 Aug 98
DoDI 6050.05	DoD Hazard Communication Program	15 Aug 06
DoDI 6055.06	DoD Fire and Emergency Services	21 Dec 06
DoDI 6055.07	Accident Investigation, Reporting and Record Keeping	03 Oct 00, Chg 1 24 Apr 08
AFI 63-101	Acquisition and Sustainment Life Cycle Management	22 Mar 11
AFI 63-1201	Life Cycle Systems Engineering	23 Jul 07
DoDD 4715.1E	Environment, Safety, and Occupational Health	19 Mar 05
DoDD 6055.9E	DoD Explosives Safety Management and the DoD Explosives Safety Board	19 Aug 05
AFI 91-202_AFSPCSUP_I	The US Air force Mishap Prevention Program	01 June 05, Certified Current 30 July 07
AFI 91-204_AFSPCSUP_I	Safety Investigations and Reports	02 Jan 07
AFI 91-217	Space Safety and Mishap Prevention Program	18 Feb 10
SMCI 63-1205	Space Systems Safety Policy, Process, and Techniques	20 Aug 07
Document No	**Standards Title**	**Issue**
MIL-STD-882C	System Safety Program Requirements	19 Jan 93
MIL-STD-882D	Department of Defense Standard Practice For System Safety	10 Feb 00
AFSPCMAN 91-710	Range Safety User Requirements Manual	01 Jul 04
AFSPCMAN 91-711	Launch Safety requirements for Air Force Space Command Organizations	01 Feb 07
AFMAN 91-201	Explosives Safety Standards	12 Jan 11
AFMAN 91-222	Space Safety Investigations and Reports	09 Aug 05
TO 00-35D-54	USAF Deficiency Reporting, Investigation, and Resolution	01 Jul 04, Chg 1 15 Mar 06
Document No	**Guidance Title**	**Issue**
	Air Force System Safety Handbook	Jul 00
CPATS	Critical Process Assessment Tool – Safety Engineering	14 Aug 98
	Software System Safety Handbook	Dec 99
	SMC Programmatic Environmental, Safety, And Health Evaluation (PESHE) Guide	25 Feb 02
ANSI/GEIA-STD-0010	Standard Best Practices for System Safety Program Development and Execution	12 Feb 09

The list of data Item Descriptions (DIDs) provided below correlate with Mil STD 882 data deliverables. SMCI 63-1205 provides the associations of these and additional DIDs with MIL-STD-882 as well as recommended tailoring.

Date Item Title	Date Item Description (DID)
System Safety Program Plan (SSPP)	DI-SAFT-81626
System Safety Hazard Analysis Report (SSHAR)	DI-SAFT-80101B
Safety Assessment Report (SAR)	DI-SAFT-80102B
Engineering Change Proposal System Safety Report (ECPSSR)	DI-SAFT-80103B
Waiver or Deviation System Safety Report (WDSSR)	DI-SAFT-80104B
System Safety Program Progress Report (SSPPR)	DI-SAFT-80105B
Health Hazard Assessment Report (HHAR)	DI-SAFT-80106B
Mishap Risk Assessment Report (MRAR)	DI-SAFT-81300A
Explosive Hazard Classification Data	DI-SAFT-81299B
Flight Termination System Report (FTSR)	DI-SAFT-80183A

System Safety Engineers' Contributions to the Acquisition Life Cycle Framework

The DoD acquisition life cycle is defined by DoDI 5000.02. System Safety contributions over this life cycle are best represented within the phase of acquisition. Figure 15 provides the acquisition life cycle framework within which SSMs perform as well as the products that the SSMs develop or contribute to their development. This figure along with SMCI 63-1205, provide requirements to perform System Safety planning, support pre and post contract award acquisition activities, and perform System Safety management and engineering across the system lifecycle. SMC Program Offices establish and implement System Safety program strategies and objectives consistent with the tenets of appropriate policies, SMC acquisition objectives, and program objectives. The Program Office develops, attains approval for, and implements System Safety planning into the System Safety Management Plan (SSMP) and higher level integrated planning (e.g., IMP) in accordance with current DoD policy. This planning is firmly based on program and technical objectives, strategies, DoD mandates, and instructions.

An effective System Safety program supports all of the major acquisition activities through the full system life cycle. The planning sufficiently defines the System Safety program to achieve the Safety and overall program objectives and requirements; specifies tasks and functions to be performed, timing of tasks, resources required, and products to be developed; forms the basis for the development of the program System Safety Management Plan (SSMP). The Safety planning and SSMP are then reflected appropriately in the ASD, RFP, SEP, TEMP, HSIP, ILSP, and other program documents that address Safety related elements. The requirements of the SSMP must also be flowed down to the Contractor's System Safety Program Plan (SSPP) and other Contractor data deliverables including the WBS and IMP. The Safety planning is executed concurrently with the SSMP that documents the process to perform, control, and integrate all Safety engineering and management activities for each phase of acquisition. The SMC Program Office's SSMP is also based upon the appropriate program-approved life cycle. The following subsections delineate System Safety contributions to acquisition activities and products by DoD acquisition Phase. Refer to SMCI 63-1205 for a more complete list of System Safety activities and products that are prepared by the Program office and their Contractors.

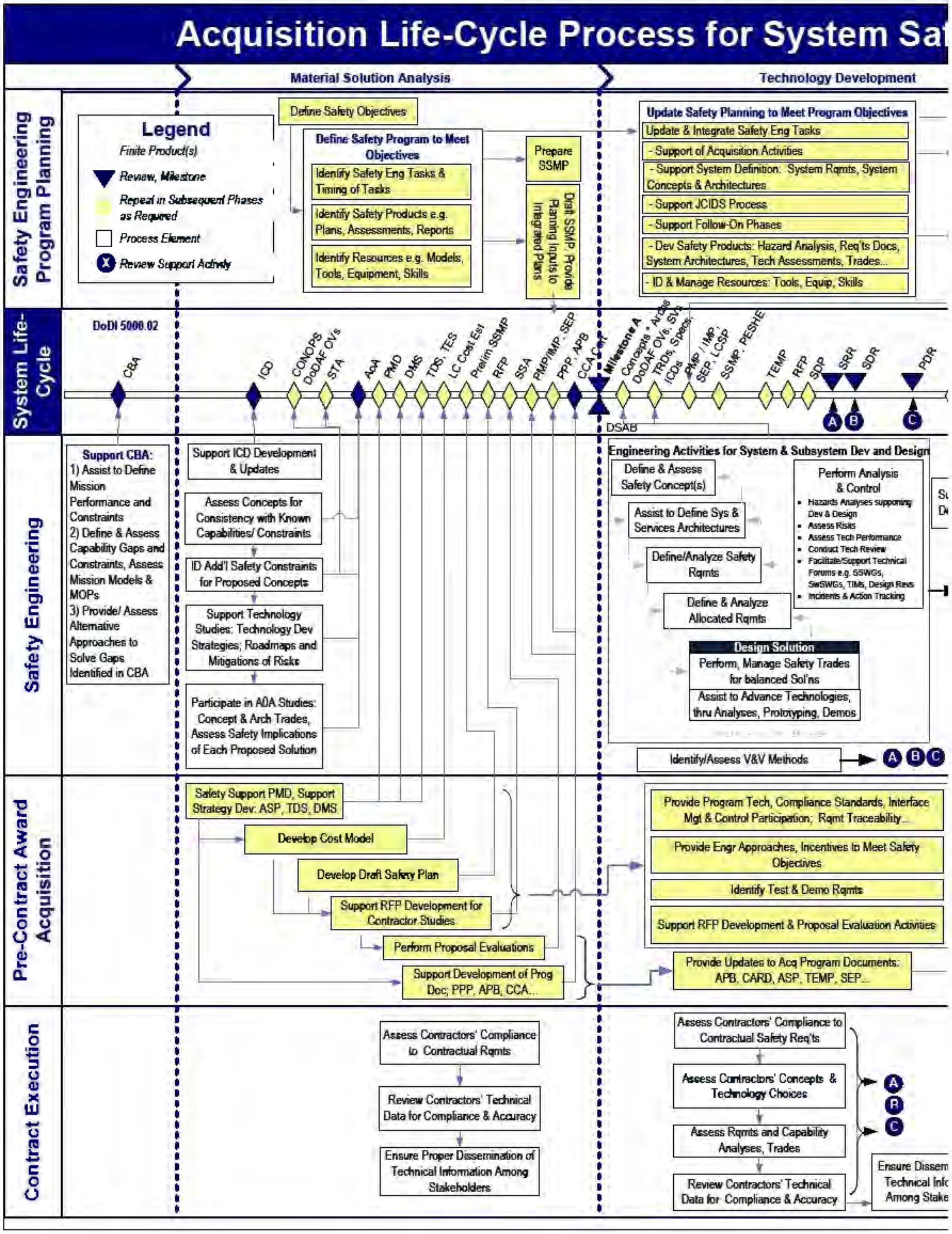
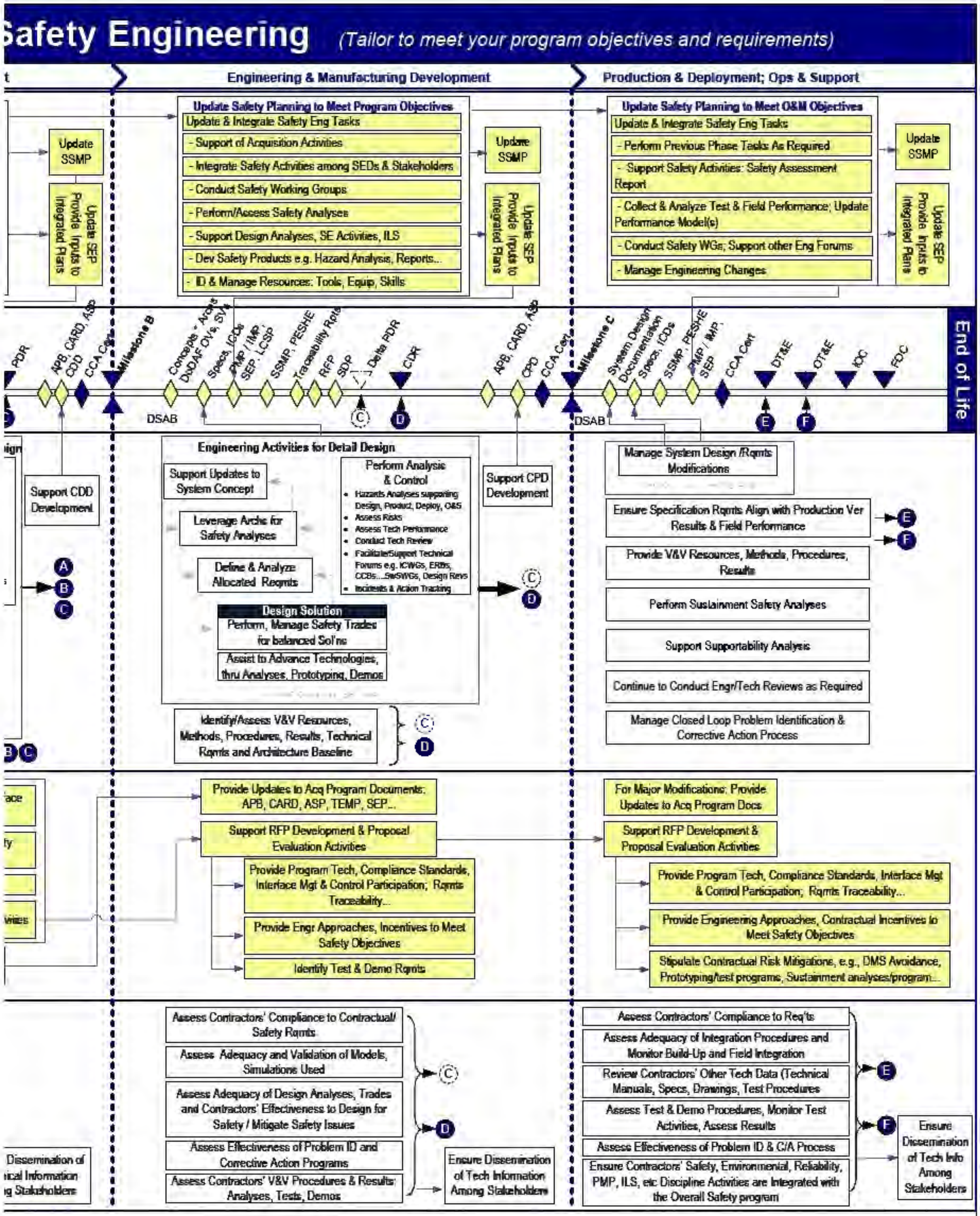


Figure 15 Acquisition life cycle process for SMC System Safety Engineering



Safety Engineering (Tailor to meet your program objectives and requirements)
Engineering & Manufacturing Development
Production & Deployment; Ops & Support
Update SSMP
Update SEP Provide Inputs to Integrated Plans
Update Safety Planning to Meet Program Objectives
Update & Integrate Safety Eng Tasks
- Support of Acquisition Activities
- Integrate Safety Activities among SEDs & Stakeholders
- Conduct Safety Working Groups
- Perform/Assess Safety Analyses
- Support Design Analyses, SE Activities, ILS
- Dev Safety Products e.g. Hazard Analysis, Reports...
- ID & Manage Resources: Tools, Equip, Skills
Update Safety Planning to Meet O&M Objectives
Update & Integrate Safety Eng Tasks
- Perform Previous Phase Tasks As Required
- Support Safety Activities: Safety Assessment Report
- Collect & Analyze Test & Field Performance; Update Performance Model(s)
- Conduct Safety WGs; Support other Eng Forums
- Manage Engineering Changes
PDR
APB, CARD, ASP
CDD
CCA Cert
Milestone B
DSAB
Concept - Archs
DoDAF OVs, SVs
Specs, ICDs
PMP / IMP, SEP, LCSP
SSMP, PESHE
Traceability Rqts
RFP
SDP
Delta PDR
CDR
APB, CARD, ASP
CPD
CCA Cert
Milestone C
System Design Documentation
Specs, ICDs
SSMP, PESHE
PMP / IMP, SEP
CCA Cert
DT&E
OT&E
IOC
FOC
End of Life
Support CDD Development
Engineering Activities for Detail Design
Support Updates to System Concept
Leverage Archs for Safety Analyses
Define & Analyze Allocated Reqmts
Perform Analysis & Control
Hazards Analyses supporting Design, Product, Deploy, O&S
Assess Risks
Assess Tech Performance
Conduct Tech Review
Facilitate/Support Technical Forums e.g. ICWGs, ERBs, CCBs…SwSWGs, Design Revs
Incidents & Action Tracking
Design Solution
Perform, Manage Safety Trades for balanced Sol'ns
Assist to Advance Technologies, thru Analyses, Prototyping, Demos
Support CPD Development
Identify/Assess V&V Resources, Methods, Procedures, Results, Technical Rqmts and Architecture Baseline
Manage System Design /Rqmts Modifications
Ensure Specification Rqmts Align with Production Ver Results & Field Performance
Provide V&V Resources, Methods, Procedures, Results
Perform Sustainment Safety Analyses
Support Supportability Analysis
Continue to Conduct Engr/Tech Reviews as Required
Manage Closed Loop Problem Identification & Corrective Action Process
Provide Updates to Acq Program Documents: APB, CARD, ASP, TEMP, SEP...
Support RFP Development & Proposal Evaluation Activities
Provide Program Tech, Compliance Standards, Interface Mgt & Control Participation; Rqmts Traceability...
Provide Engr Approaches, Incentives to Meet Safety Objectives
Identify Test & Demo Rqmts
For Major Modifications: Provide Updates to Acq Program Docs
Support RFP Development & Proposal Evaluation Activities
Provide Program Tech, Compliance Standards, Interface Mgt & Control Participation; Rqmts Traceability...
Provide Engineering Approaches, Contractual Incentives to Meet Safety Objectives
Stipulate Contractual Risk Mitigations, e.g., DMS Avoidance, Prototyping/test programs, Sustainment analyses/program...
Assess Contractors' Compliance to Contractual/ Safety Rqmts
Assess Adequacy and Validation of Models, Simulations Used
Assess Adequacy of Design Analyses, Trades and Contractors' Effectiveness to Design for Safety / Mitigate Safety Issues
Assess Effectiveness of Problem ID and Corrective Action Programs
Assess Contractors' V&V Procedures & Results: Analyses, Tests, Demos
Ensure Dissemination of Tech Information Among Stakeholders
Assess Contractors' Compliance to Req'ts
Assess Adequacy of Integration Procedures and Monitor Build-Up and Field Integration
Review Contractors' Other Tech Data (Technical Manuals, Specs, Drawings, Test Procedures
Assess Test & Demo Procedures, Monitor Test Activities, Assess Results
Assess Effectiveness of Problem ID & C/A Process
Ensure Contractors' Safety, Environmental, Reliability, PMP, ILS, etc Discipline Activities are Integrated with the Overall Safety program
Ensure Dissemination of Tech Info Among Stakeholders

1. **Materiel Solution Analysis.** During this phase the SSM provides inputs to and supports most program acquisition activities to include the development of the acquisition strategy, inputs to the cost estimates, solicitation/RFP development for Contractor studies, and proposal evaluation activities. The SSM prepares a draft System Safety Management Plan (SSMP) and also contributes to the development of the MSA Phase acquisition products.

MSA Phase – SMC Acquisition Products
PMD
ASP, TDS, DMS, TES
LC Cost Estimate
RFP inputs (operations & system safety requirements; Safety assessment requirements; High level Safety assessments of concepts, CDRL, PHL, proposal evaluation criteria, contract language)
APB, CCA
Draft SSMP, SSG/SSWG Charters
SEP, LCMP

2. **Technology Development.** The SSM provides inputs to and supports all program acquisition activities to include the development of the acquisition strategy, updates to the cost model and development of the Cost Analysis Requirements Description (CARD), solicitation/RFP development and proposal evaluation activities. The SSM identifies other contract requirements such system safety requirements, safety related tasks, test & demo requirements to meet Safety objectives. The SSM also contributes to the development and updates to the TD Phase acquisition products to include the review/comment/approval of system safety data deliverables.

TD Phase – SMC Acquisition Products
Updates to ASP, TDS, DMS
LC Cost Estimate Update / CARD Development
RFP: Safety objectives in the SOO; Safety related tasks in SOW, Safety data products in CDRLs (SSPP, PHAR; SMC- Safety standards - tailored
SSMP update; PESHE, Draft SDAR & EOLP,
APB: Safety objectives & related concept descriptions
Detailed Safety planning (SSMP), SEP, LCMP, TEMP, HSIP

3. **Engineering & Manufacturing Development.** The SSM provides inputs to and supports all program acquisition activities to include updates to the acquisition strategy and updates to the cost model to reflect the actual technical solutions determined and updates to the CARD. The SSM supports the solicitation/RFP development and proposal evaluation activities which include providing the technical inputs including technical requirements, compliance standards, engineering approaches, incentives, and warranty programs to meet program objectives. The SSM identifies other contract requirements as necessary to meet System Safety objectives. The SSM also contributes to the development and updates to the EMD Phase acquisition products which includes the review/comment/approval of system safety data deliverables.

EMD Phase – SMC Acquisition Products
Updates to ASP, TDS, DMS
CARD update
RFP: Safety objectives in the SOO; Safety related tasks in SOW, Safety data products in CDRLs (SSHA, SHA, O&SHA); SMC- Safety standards - tailored
SSMP; PESHE, SDAR, EOLP
APB: Safety objectives & related concept descriptions
Detailed Safety planning, SEP, LCMP, TEMP, HSIP updates

During EMD the SSM ensures that hazardous materials are documented in the Programmatic Environment, Safety, and Occupational Health Evaluation (PESHE) and ensures that the SMC Program Office estimates and plans for the system's demilitarization and safe disposal. The demilitarization of conventional ammunition (including any item containing propellants, explosives, or pyrotechnics) must be considered during system design.

P&D / O&S Phase – SMC Acquisition Products
Updates to ASP, TDS, DMS
RFP: Safety objectives in the SOO; Safety related tasks in SOW, Safety data products in CDRLs; SMC-Safety standards - tailored
Updates: SSMP; PESHE
Detailed Safety planning, SEP, LCMP, TEMP, HSIP updates
CARD update

4. **Production & Deployment, Operations & Support.** The SSM provides inputs to and supports all program acquisition activities to include updates to the acquisition strategy and updates to the cost model to reflect the actual technical solutions determined and updates to the CARD. The SSM supports the solicitation/RFP development and proposal evaluation activities. The SSM identifies other contract requirements: production and field test & demo requirements; field performance and sustainment analyses to meet system safety objectives. At the end of the system's useful life, the SSM ensures that the system is demilitarized and disposed of in accordance with legal and regulatory requirements and policy relating to ESOH.

System Safety Engineers' Contributions to Engineering Life Cycle Framework

Relationship to the SE Organization

The SSM plans and executes the essential system safety engineering and management efforts in an integrated and effective manner within the context and full support of the overarching Systems Engineering function. The SSM ensures that their SED contributions are timely, adequate, consistent, and compliant and system safety contributions are channeled through the Systems Engineering *Analyses and Control* activity.

Systems Engineers manage the engineering process and activities depicted Figure 3 while the System Safety Engineer contributes to this process. System Safety Engineers support concept and architecture development and analyses; modeling and simulation efforts; technology studies. The System Safety Engineers develop/derive safety related requirements and supports the requirements analyses and allocations process. They also participate in technical studies and technical solutions trades when safety is a factor. They provide design analyses contributions to determine potential hazards and safety related risks. They assess and propose alternative mitigating actions or solutions. The System Safety Engineer also works closely with the System Engineers performing interface analyses and functional analyses to leverage the required safety related analyses. The System Safety Engineer also supports the integration and verification and validation planning and execution.

In performing the management and control function, the Systems Engineer effectively integrates all engineering functions through the full system life cycle. The System Safety Engineer ensures their technical contribution to the overall engineering advances and is appropriately applied through systematic control, collaboration and sharing across the organization. For example, their assessment products, e.g., hazards assessments are timed to coincide with architectural trades, design trades, reliability analyses (fault tree, fishbone, failure modes, critical items lists, reliability block diagrams, etc). In addition the System Safety Engineers products are timed and applied by the other Specialty Engineers to perform their unique contributions (and vice versa), and must be provided to technical and program management for decision making.

Relationship to other SEDs

The System Safety Engineer SED relationship to other SEDs is summarized in Figure 1. System Safety interactions with the other SEDs are critical to perform and integrate their engineering contributions to the system development efforts. When failure analyses results indicate potential safety impacts, The System Safety engineer assists to adjust reliability allocations and ensure confidence in attaining safety requirements through analyses, demo, and test. The figure below illustrates how the System Safety Engineer performs analyses and integrates that effort with the Systems Engineer, Reliability Engineer, and Risk Manager.

The System Safety Engineer works closely with the Logistics Engineers performing maintenance and sustainment analyses to identify and address safety related issues or risks. The System Safety Engineer aligns closely with the Quality Assurance and Quality Engineer to ensure safe operations during production, handling, storage, packaging, and transportation.

Tools Selection and Use

The System Safety Engineer considers effectiveness and efficiencies gained by selecting and using the best choice of safety tools considering the safety tool requirements possibly for safety / hazards analyses, information sharing, automated data exchanges with other tools, and other considerations.

Typical Safety Functions Requiring Tools
Hazards identification, analyses & reporting
Incidents & action tracking
Fault tree, failure modes; probabilistic failure analyses (See RAM SED)

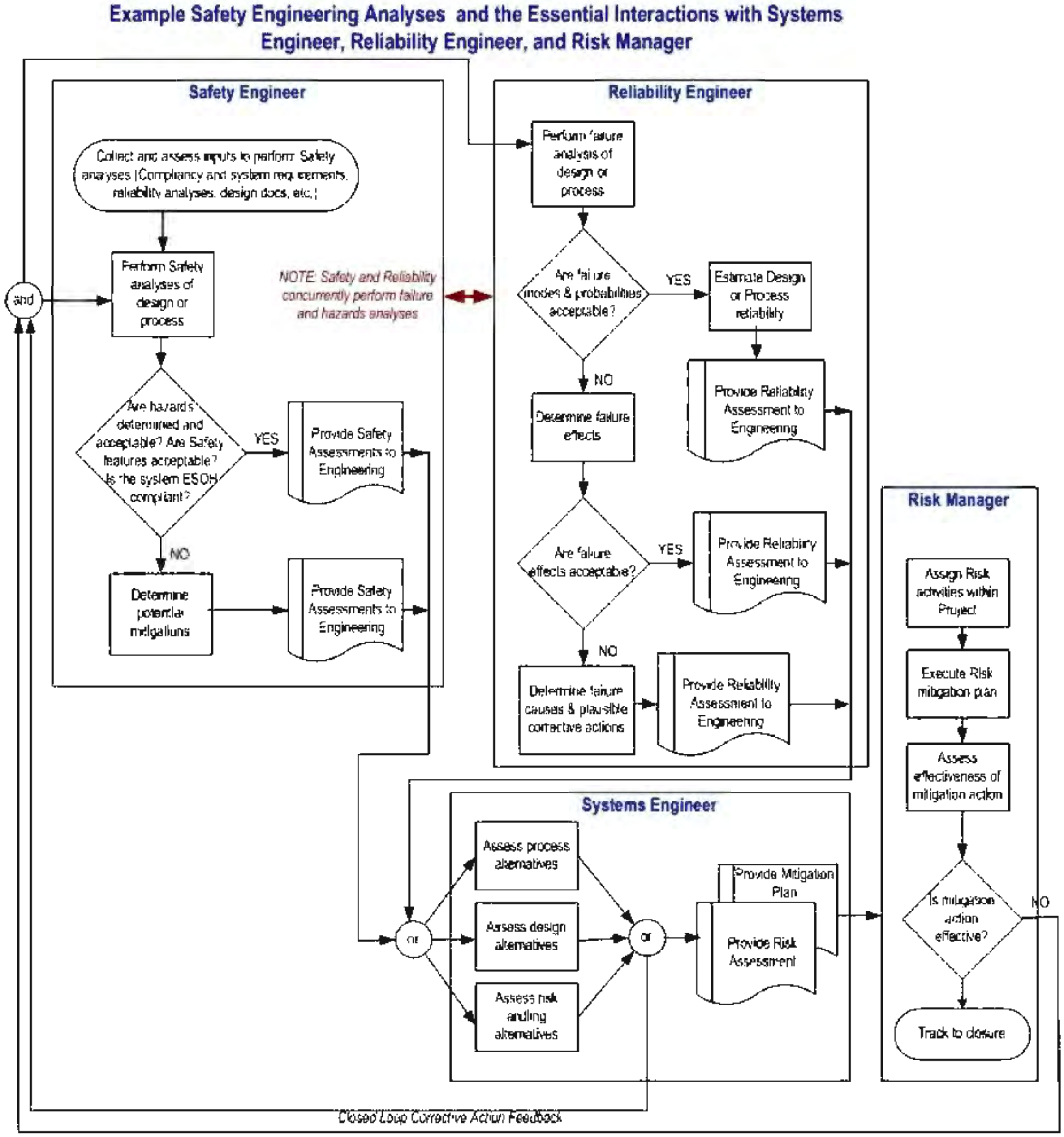


Figure 16 Example interaction between System Safety, Systems Engineer, Reliability Engineer, and Risk Manager

Engineering Activities and Products over the Life Cycle

Engineering activities that are unique to System Safety include:

- Identify, evaluate, and control system safety and health hazards throughout the system's life cycle.
- Define and document mishap risk levels including associated mishap risk acceptance processes.
- Establish a program that manages and documents the probability and severity of all hazards associated with development, use and disposal of the system.
- Manage all safety and health risks in a manner that is cost effective and consistent with mission requirements.
- Ensure that space safety (launch and orbital safety) requirements are established and implemented for all space systems. Launch safety includes launch operations safety, flight safety analysis, and mission flight control; orbital safety covers the post-launch phase of a space system and includes the control and minimization of hazards related to orbital debris, collision avoidance, laser clearing-house functions, environmental hazards, and safety procedures.
- Establish an explosives safety program that ensures munitions, explosives, and energetics are properly hazard classified, and safely developed, manufactured, tested, transported, handled, stored, maintained, demilitarized, and disposed. Comply with DoD explosives safety requirements in all acquisition programs that include or support munitions, explosives, or energetics. Evaluate and manage the use and selection of energetic materials and the design of munitions and explosive systems to reduce the possibility and the consequences of any munitions or explosives mishap to optimize the trade-off of munitions reliability against unexploded ordinance liability.

The following subsections delineate System Safety contributions to engineering activities and technical products by DoD acquisition phase. Refer to SMCI 63-1205 for a more complete list of System Safety activities and products prepared by the Program Office and their Contractors.

1. **Materiel Solution Analysis.** During this phase the System Safety Engineer may provide inputs to and support the Capabilities Based Assessment process and the JCIDS process. The System Safety Engineer evaluates proposed concepts and architectures to identify and assess implications of energetic materials, explosives, hazardous materials and provide recommendations for each alternative. The System Safety Engineer assists to define / refine operational and system safety related requirements to support ICD development and possibly TRD development. The System Safety Engineer also contributes to the development of the MSA Phase technical products.

MSA Phase – Technical Products Required	
SMC Safety Technical Products	**Contributions to Other Organizations' Products**
High level assessment proposed concepts & architectures	Operational Concepts
Safety engineering inputs and factors for concept, architecture, technology studies, and trades	AoA Studies
System Safety Req'ts (draft)	Initial Capabilities Doc (ICD) Dev
Roadmap and architectural inputs – Identification & mitigations of Safety risks	DoDAF CVs, OVs

2. **Technology Development.** During this phase the System Safety Engineer continues to provide inputs to and supports the JCIDS process. The System Safety Engineer also supports all the engineering activities highlighted within the box titled *Engineering Activities for System & Segment Development & Design* Figure 15 to commence system definition and development. System Safety Engineer develops and contributes to development of the TD Phase technical products.

TD Phase – Technical Products Required	
SMC Safety Technical Products	**Contributions to Other Organizations' Products**
Inputs to System Concepts	Operational Concepts
Factors for Studies/ Trades	Operational Assessments
Safety Tech Req'ts, TRD, SRD, Specifications, ICDs, Standards Selection/ Tailor	Capabilities Development Doc (CDD)
Safety inputs to ISP	DoDAF CVs, OVs
Prelim hazards list	
PESHE	

3. **Engineering & Manufacturing Development.** System Safety Engineer continues to provide inputs to and supports the JCIDS process. The System Safety Engineer supports all the engineering activities highlighted within the box titled *Engineering Activities for Detailed Design* Figure 15 to commence detailed systems definition and development. The System Safety Engineer ensures process is in place to report, analyze, and mitigate safety / hazards data during DT&E. The System Safety Engineer provides inputs to and supports the JCIDS process. The activities of Safety during this phase are extensive. Refer to SMCI 63-1205, *SMC Safety Policy, Process, and Techniques* for Safety Engineer activities and products typically required during each phase. The System Safety Engineer develops and contributes to the development of the EMD Phase technical products.

EMD Phase – Technical Products Required	
SMC Safety Technical Products	**Contributions to Other Organizations' Products**
Update System Concept	Operational Concepts
Technical Studies/ Trades	Operational Assessments
System Tech Req'ts, TRD, SRD, Spec, ICDs; Safety requirements flow-down / allocations	Capabilities Production Doc (CPD)
Inputs to system design, production, fielding, sustain docs	DoDAF CVs, OVs
PESHE Update	
Safety inputs to ISP	
Safety / hazards analyses/report	
Safety evaluations of Tech Orders, operations manuals	
Test, Demo reports	

4. **Production & Deployment, Operations & Support.** The System Safety Engineer continues to ensure design meets the contractual safety requirements and manufacturing, build and integration activities do not induce additional safety risks. The System Safety Engineer ensures the Safety program appropriately addresses orbital safety: collision avoidance, directed energy, end-of-life safing, and space environments per AFSPC Supplement to AFI 91-202. Refer to SMCI 63-1205, *SMC Safety Policy, Process, and Techniques* for Safety Engineer activities and products typically required during this phase. The Safety Engineer develops and contributes to the development of the P&D / O&S Phase technical products.

P&D / O&S Phase – Technical Products Required	
SMC Safety Technical Products	**Contributions to Other Organizations' Products**
Inputs tech baseline engineering changes	Supportability assessment Rpt Contribution
Analyses of failures and mishap incidents	Operational Assessments Contributions
Hazards analyses Report.	Transition & Fielding Docs
SSMP & PESHE Update	
T&E / Demo, Safety Reports	
Safety evaluations of Tech Orders, operations manuals	

System Safety Manager's Contribution to Program and Project Management

Each SMC program defines their business model and approach structure based primarily on their program objectives, program and technical challenges, organizational structure, as well as program and engineering planning (SEP plus detailed SSMP).

The System Safety Manager (SSM) develops and implements the SSMP to achieve Program Office system safety objectives and requirements. The planning defines the system safety tasks and functions to be performed and products to be developed; timing of tasks, task outputs, resources (skills, tools, equipment, and completion criteria). The SSM plans tasks to integrate safety activities within the Program Office, between Contractors and government stakeholders. The SSM plans the tasks to establish and manage hazards; conduct system safety forums; support SE&I activities, risk management, integration, and system modifications; coordinate the system safety planning with SMC Staff Safety Office, operating commands, supporting commands, and test agencies; integrate system safety planning with other functional and acquisition plans (i.e. ASD, RFP, SEP, TEMP, ASP, LCMP).

Execution of the System Safety planning is typically defined in the SSMP which implements SMC and higher level instructions, policies, and directives. The SSM provides full support to define the program and technical objectives where system safety challenges and risks are known or anticipated. The SSM assists to establish the business model, develop program planning and schedules, and define and implement program processes. The SSM ensures the system safety components of the program are appropriately represented in the program plans, program schedules, work breakdown structures, and cost estimates. The SSM also reports their technical performance and progress. The SSM shares in the risk management responsibilities to identify, assess, and propose mitigating actions of system safety related risks. The SSM also support the program manager's problem identification, resolution, and decision-making processes.

The SSM contributes to the development of the program management products identified in the Table.

SMC Program Management Products
PMD
ASD, SSMP, SEP, PESHE, TEMP, HSIP, ILSP
Decision-making & problem solving inputs
Technical progression and issues reporting
LC Cost Estimate (CARDs)
Processes (OIs)
Risk Management Inputs

Appendix L – Acquisition Systems Protection & International Program Security

Program protection planning is integral to the overall acquisition strategy and is performed at the front end of the program. The program identifies Critical Program Information (CPI) for the acquisition program IAW DoDI 5200.39, AFPM 63-1701, and AFPD 63-17. CPI applies to components, engineering, design, manufacturing processes, or technologies that, if compromised, could cause significant degradation in mission effectiveness, shorten the expected combat-effective life of the system, or reduce technological advantage (DoDI 5200.39).

The Program Protection Engineer (PPE) identifies the resources needed to accomplish the evaluation and initiates protection, if required, at the earliest possible.

The required extent of program protection (PP) strongly depends on the nature, significance, and criticality of CPI identified for the program and the overall DoD mission. If no CPI is identified, only a program letter stating the fact is required which is then approved by the decision authority.

If it is determined that the program contains CPI, a program protection plan (PPP) is required during the technology development phase and made available to the decision authority at Milestone B. For cooperative programs with foreign participation, a technology assessment and control plan (TA/CP) is required IAW DoDI 5200.39, DoD 5220.22M, DoDD 5530.3, and DoDI S-5230.28, as an annex to the PPP. Furthermore, a Delegation of Disclosure Authority Letter (DDL) IAW DoDD 5230.11, enclosure 4, is also produced as an annexure to the PPP.

Depending on the nature and significance of the CPI other documents, usually annexed to the PPP, are required that include (i) Counterintelligence (CI) support plan, (ii) System Security Management Plan (SSMP) IAW MIL-HDBK-1785, (iii) Security Classification Guide (SCG) IAW DoD 5200.1-R and DoD 5200.1-H, (iv) OPSEC plan IAW DoDD 5205.02 and DoDD 5205.02-M, and (v) classified anti-temper (AT) plan.

This section on program protection engineering should be read in conjunction with the sections on Information Assurance (IA) and Net-centric Engineering (NCE) SEDs.

Applicable governance, standards, and guidance

Table 17 identifies the significant governance, standards, and guidance which generally require SMC compliance for program protection engineering.

Table 17 Governance, standards, and guidance that shape the Program Protection Engineering discipline

Document No	Governance Title	Issue
DoDD 5000.01	Defense Acquisition System, E1.1.9. Information Assurance	20 Nov 07
DoDI 5000.02	Operation of the Defense Acquisition System, "Title 40/Clinger Chen Act (CCA)" Compliance	08 Dec 08
DoDM5200.39 Change 1	Critical Program Information (CPI) Protection Within the Department of Defense	28 Dec 10
DoD 5200.1-R and DoD 5200.1-H, Change 1	DoD Information Security Program and Protection of Sensitive Compartmented Information	13 Jun 11

DoDD 5205.02 and DoDD 5205.02-M	DoD Operations Security (OPSEC) Program Manual	03 Nov 08
DoDD 5530.3 Change 1	International Agreements: Enclosure 7. Technology Assessment/Control Plan (TA/CP) International Agreements	18 Feb 91
DoDI S-5230.28	Technology Assessment/Control Policy on export restrictions (?)	26 May 05
DoDD 5230.11	Disclosure of Classified Military Information to Foreign Governments and International Organizations: Enclosure 4. Delegation of Disclosure Authority Letter (DDL) on foreign collaboration	16 Jun 92
MIL-HDBK-1785	System Security Program Management Requirements	01 Aug 95
AFPM 63-1701	Program Protection Planning	27 Mar 03
AFPD 63-17	Technology and Acquisition Systems Security Program Protection	02 Apr 07
Document No	**Standards Title**	**Issue**
AFPM 63-1701	Program Protection Planning (PPP)	27 Mar 03
Document No	**Guidance Title**	**Issue**
-	DASD for Cyber, Identity, and Information Assurance Strategy	Aug. 09
Defense Acquisition Guidebook (DAG)	DAG, Chapter 8: Intelligence, Counterintelligence, and Security Support, Section 8.4 Acquisition Protection Strategy for Program Managers	Current at https://dag.dau.mil/

PPE's Contributions to the Acquisition Life Cycle Framework

Effective program protection planning begins by the appointed PPE reviewing the acquisition program to determine if it contains CPI. If there is no CPI associated with the program, the appropriate authority or acquisition executive is informed accordingly, and no further program protection documentation is required.

If review identifies CPI, whether new or inherited from other programs, PPP is required. The document is developed during the technology development phase and it is first presented to the milestone decision authority at milestone B. It is updated for each subsequent milestone. During operations, the PPP is revised and updated once every three years, or as required by changes to acquisition program status or the projected threat.

The PPP is used to coordinate and integrate all protection efforts designed to deny access to CPI to anyone not authorized or not having a need-to-know and prevent inadvertent disclosure of leading edge technology to foreign interests. If there is to be foreign involvement in any aspect of the program, or foreign access to the system or its related information, the PPP contains provisions to deny inadvertent or unauthorized access. The PPE and his technology protection team is responsible for developing and implementing PPP. Counterintelligence (CI) and security support activities and program protection staff elements also assist the PPE in identifying CPI.

After the protection planning foundation is laid, the program proceeds through the milestones and phases of the acquisition process. The program follows an event-based schedule that implements the protection strategy and completes the actions outlined in the PPP.

Figure 17 shows the PP engineering contributions and required products within the phased acquisition lifecycle framework. This figure delineates the Program Office PP engineering responsibilities and requirements to perform PP planning, support pre- and post-contract award acquisition activities, and performs PP engineering management across the system lifecycle, consistent with the tenets of appropriate policies, SMC acquisition objectives, and overall program SE objectives. The Program Office PPE helps develop, attain approval for, and implement the PPP and related artifacts that may include CI support plan, Security Classification Guide (SCG), OPSEC plan, Anti-Tamper (AT) plan, and TA/CP to comply with I&S requirements in accordance with current DoD policy. SMC Program Offices appoint establish and implement program protection strategies and objectives consistent with SMC acquisition objectives.

The following paragraphs provide a listing of activities and the required PP engineering products.

1. **Materiel Solution Analysis.** During this phase, the SMC PM or equivalent appoints or assumes responsibilities of the PPE. The PPE reviews program objectives, descriptions, and other relevant data to identify CPI. The need to collaborate or share CPI with foreign entities is also established. PPE also provides inputs to the overall systems engineering, initial capabilities document, cost estimates for program protection, solicitation/RFP development for contractor studies, and proposal evaluation activities as necessary.

MSA Phase – SMC Acquisition Products
Identification and list of CPI
CPI Section in ICD, APB

2. **Technology Development.** For MS B, PPE: (i) ensures PP considerations are incorporated in the program ASP, (ii) updates list of CPI, (iii) ascertains collaboration or sharing of CPI with foreign or commercial interests and develops technology assessment/control plan as necessary, (iv) performs PP risk assessment and develops counterintelligence support plan integral to the overall SE process, (v) secures resources for PP budget, and (vi) supports RFP development effort to ensure adequate CPI protection.

TD Phase – SMC Acquisition Products
Updates to list of CPI
Military Critical Technology List citations for applicable CPI
Foreign disclosures as necessary
Initial PPP
RFP: PP objectives in the SOO; PP related tasks in SOW, PP planning data products in CDRLs;

3. **Engineering & Manufacturing Development.** For MS C, the PPE updates the PPP including its foreign disclosures annexes and security classification guide based on updated risk management plan, CI support plan and other analyses integral to the overall SE process. PPE supports RFP development by evaluating and mitigating risk in contract vehicles that may result in unfavorable sharing or export of certain technologies and CPI.

EMD Phase – SMC Acquisition Products
Update PPP
Update Foreign disclosures as necessary
RFP: PP objectives in the SOO; PP related tasks in SOW, PP planning data products in CDRLs;

4. **Production & Deployment, Operations & Support.** The PPE maintains system's PP plan throughout its lifecycle. It includes periodic assessment of CPI, review and approval foreign disclosure posture, and review and approval of PPP by the MDA.

P&D / O&S Phase – SMC Acquisition Products
Update PPP at deployment
Update PPP every 3 years during operations

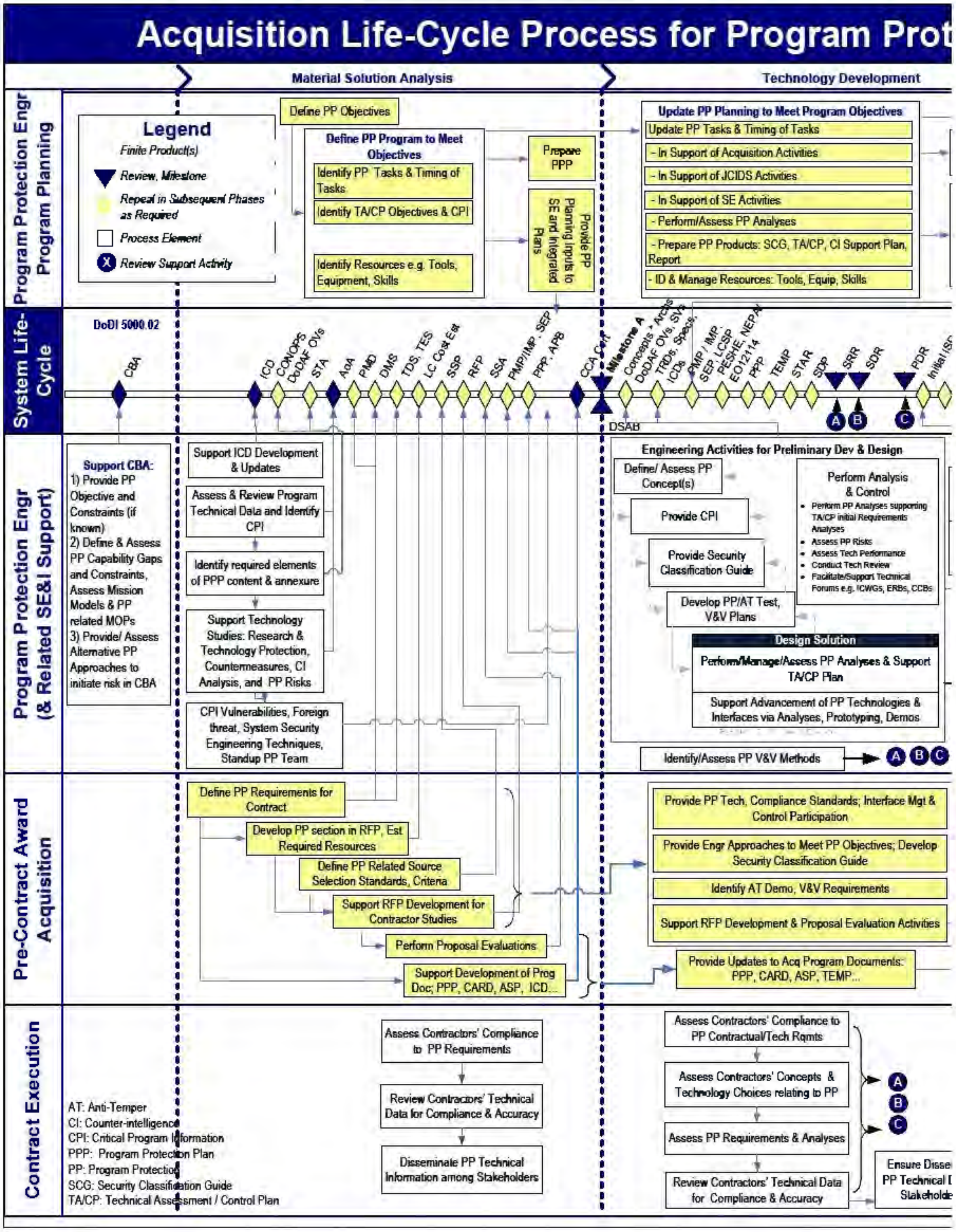
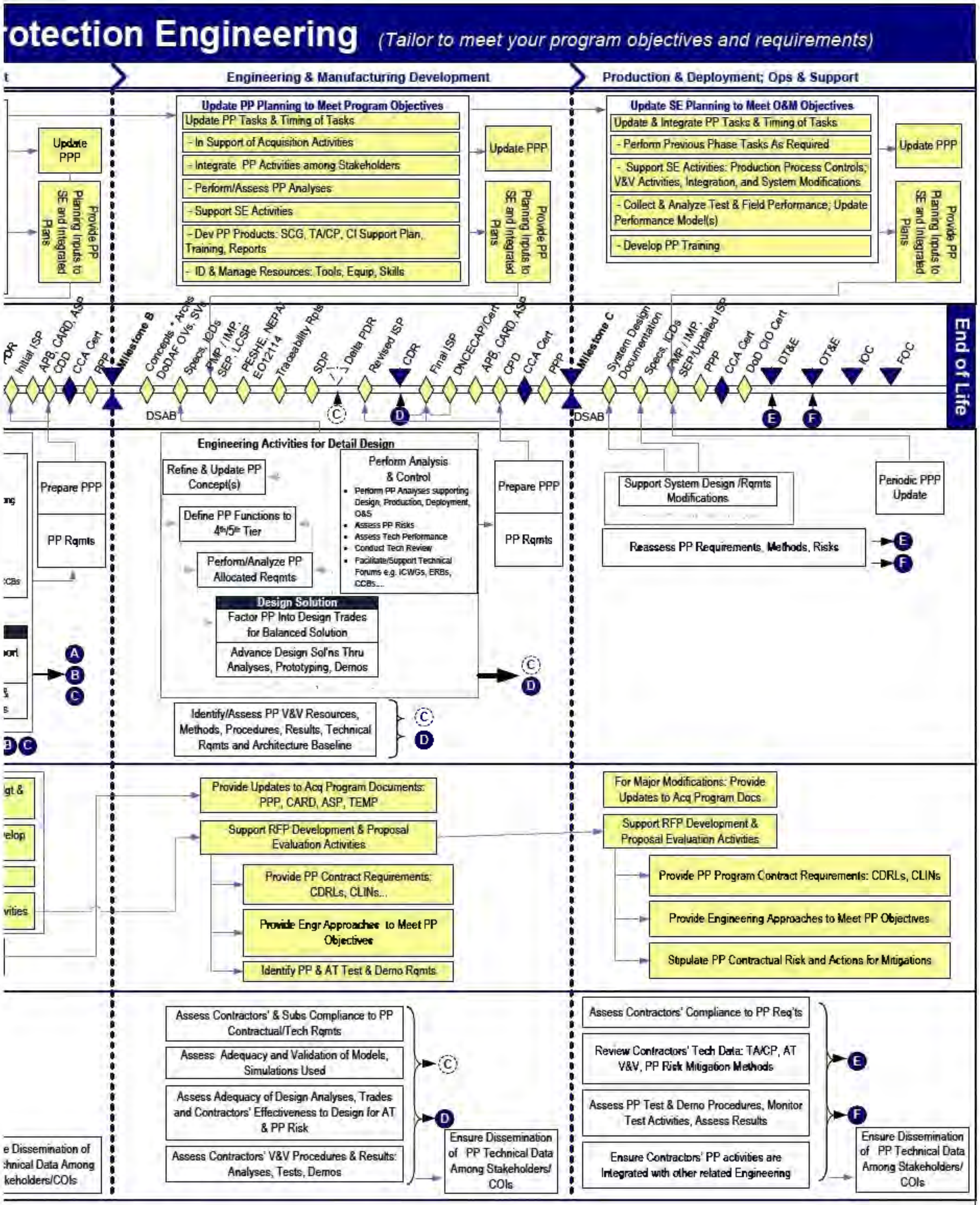


Figure 17 Acquisition life cycle process for SMC Program Protection Engineering


otection Engineering (Tailor to meet your program objectives and requirements)
Engineering & Manufacturing Development
Production & Deployment; Ops & Support
Update PP Planning to Meet Program Objectives
Update PP Tasks & Timing of Tasks
- In Support of Acquisition Activities
- Integrate PP Activities among Stakeholders
- Perform/Assess PP Analyses
- Support SE Activities
- Dev PP Products: SCG, TA/CP, CI Support Plan, Training, Reports
- ID & Manage Resources: Tools, Equip, Skills
Update PPP
Provide PP Planning Inputs to SE and Integrated Plans
Update SE Planning to Meet O&M Objectives
Update & Integrate PP Tasks & Timing of Tasks
- Perform Previous Phase Tasks As Required
- Support SE Activities: Production Process Controls; V&V Activities, Integration, and System Modifications
- Collect & Analyze Test & Field Performance; Update Performance Model(s)
- Develop PP Training
End of Life
Milestone B
Milestone C
DSAB
Engineering Activities for Detail Design
Refine & Update PP Concept(s)
Define PP Functions to 4th/5th Tier
Perform/Analyze PP Allocated Reqmts
Perform Analysis & Control
Design Solution
Factor PP Into Design Trades for Balanced Solution
Advance Design Sol'ns Thru Analyses, Prototyping, Demos
Prepare PPP
PP Rqmts
Identify/Assess PP V&V Resources, Methods, Procedures, Results, Technical Rqmts and Architecture Baseline
Support System Design /Rqmts Modifications
Periodic PPP Update
Reassess PP Requirements, Methods, Risks
Provide Updates to Acq Program Documents: PPP, CARD, ASP, TEMP
Support RFP Development & Proposal Evaluation Activities
Provide PP Contract Requirements: CDRLs, CLINs...
Provide Engr Approaches to Meet PP Objectives
Identify PP & AT Test & Demo Rqmts
For Major Modifications: Provide Updates to Acq Program Docs
Support RFP Development & Proposal Evaluation Activities
Provide PP Program Contract Requirements: CDRLs, CLINs
Provide Engineering Approaches to Meet PP Objectives
Stipulate PP Contractual Risk and Actions for Mitigations
Assess Contractors' & Subs Compliance to PP Contractual/Tech Rqmts
Assess Adequacy and Validation of Models, Simulations Used
Assess Adequacy of Design Analyses, Trades and Contractors' Effectiveness to Design for AT & PP Risk
Assess Contractors' V&V Procedures & Results: Analyses, Tests, Demos
Ensure Dissemination of PP Technical Data Among Stakeholders/ COIs
Assess Contractors' Compliance to PP Req'ts
Review Contractors' Tech Data: TA/CP, AT V&V, PP Risk Mitigation Methods
Assess PP Test & Demo Procedures, Monitor Test Activities, Assess Results
Ensure Contractors' PP activities are Integrated with other related Engineering

PPE's Contributions to the Engineering Life Cycle Framework

When the acquisition program contains Critical Program Information (CPI), the PPE initiates a program protection planning process that includes: (i) identify and prioritize CPI, (ii) Identify the foreign collection threat to the program, (iii) identify specific program vulnerabilities and risk, (iv) identify Research and Technology Protection (RTP) countermeasures to reduce, control, or eliminate risk, (v) identify AT techniques and system security engineering (SSE) measures to protect CPI and integrate these techniques with the overall SE design, (vi) identify and document classification needs in Security Classification Guide, (vii) identify protection costs associated with personnel, products, services, equipment, contracts, and facilities, (viii) identify the risks and benefits of developing, producing, or selling the system to a foreign interest, (ix) identify contractual actions required to ensure that planned SSE, AT techniques, IA, classification management, and/or RTP countermeasures are appropriately applied by defense contractors, and (x) coordinate with supporting programs to ensure that measures taken to protect CPI are maintained at an equivalent level throughout the DoD and its supporting contractors.

The details in PPP are limited to information needed to protect CPI and an executable plan to implement associated countermeasures over the entire lifecycle of the acquisition. While there is no specific format for PPPs, the PPE is expected to develop the following content:

- A list of program CPI;
- Counterintelligence (CI) Analysis of CPI: When an acquisition program containing CPI is initiated, the Program Manager (PM) should request a CI Analysis of CPI from the servicing CI organization. The CI Analysis focuses on how the opposition sees the program and on how to counter the opposition's collection efforts. The CI analyst, in addition to having an in-depth understanding and expertise on foreign intelligence collection capabilities, must have a good working knowledge of the U.S. program. Therefore, CI organizations need information that describes the CPI and its projected use to determine the foreign collection threat to an acquisition program. The CI analytical product that results from the analysis will provide the PM with an evaluation of foreign collection threats to specific program or project technologies, the impact if that technology is compromised, and the identification of related foreign technologies that could impact program or project success. The CI analytical product is updated as necessary (usually prior to each major milestone decision) throughout the acquisition process. Changes are briefed to the program or project manager within 60 days.
- Vulnerabilities of CPI;
- All Research and Technology Protection (RTP) countermeasures (e.g., anti-tamper techniques, system security engineering) and Military Critical Technology List citations for applicable CPI;
- All RTP associated costs, by Fiscal Year, to include PPP development and execution;

- CI Support Plan (CISP): The CISP defines specific counterintelligence (CI) support to be provided to the research, development, test and evaluation (RDT&E) facility or acquisition program and provides the servicing CI personnel with information about the facility or program being supported. A tailored CISP is developed for every DoD RDT&E activity and for each DoD acquisition program with identified Critical Program Information (CPI); RDT&E site directors, security managers, and supporting CI organizations are responsible for developing a CISP for each RDT&E facility; Program managers (PMs) and their supporting security and CI organizations are responsible for developing a CISP for each acquisition program with CPI. The CPI will be listed in the CISP.

- Current Security Classification Guide:

- Foreign disclosure, direct commercial sales, co-production, import/export license or other export authorization requirements, and/or Technology Assessment/Control Plan (TA/CP) IAW DoDD 5530.3 and Intelligence Community Directive (ICD) 301. The TA/CP analysis often assists in developing vulnerabilities and proposed RTP countermeasures.

- Delegation of Disclosure Authority Letter: The program manager must prepare a DDL as part of a recommendation for foreign involvement, disclosure of the program to foreign interests, request for authority to conclude an international agreement, or a decision to authorize foreign sales.

- Anti-Tamper Plan: Program managers develop and implement anti-tamper (AT) measures to protect Critical Program Information (CPI) in U.S. defense systems developed using co-development agreements, sold to foreign governments, or no longer within U.S. control (e.g., theft, battlefield loss). The DoD Anti-Tamper Executive Agent (ATEA) resides with the Department of the Air Force. AT implementation is tested and verified during developmental test and evaluation and operational test and evaluation. PPE develops the validation plan to secure necessary funding for the AT V&V on actual or representative system components. The V&V plan is developed to support Milestone C, is reviewed and approved by the AAF ATEA, and validation results are reported to the Milestone Decision Authority.

- System Security Management Plan (SSMP): If necessary, the PPE helps develop the SSMP for the program to integrate RTP into the systems engineering process IAW MIL-HDBK-1785.

- DoD Information Assurance Certification and Accreditation Process (DIACAP) certification: All information and space systems must comply with the DIACAP requirements IAW DoDD 8500.01.

- PPE develops the Program Security Instruction, if appropriate.

It is PPE's responsibility to ensure that risk associated with the program protection is seamlessly integrated with the overall SE risk management effort. Within the global context of IA, PPE applies risk management process to identify, evaluate, rank, and control loss of technology. PPP preparation is based on systematic risk management, not risk avoidance. Costs associated with protecting CPI are balanced between protection costs and potential impact if compromised. The program accepts residual risk with approval from the Milestone Decision Authority. The PPP is classified according to content.

Relationship to SE Organization

The PPE plans and executes the program protection engineering and management efforts in an integrated and effective manner within the context and full support of the overarching Systems Engineering (SE) function. PPE ensures that each program protection SED contribution is timely, adequate, consistent, and compliant. The PPE and his team ensure that their contributions are channeled through the Systems Engineering *Analyses and Control* activity.

Program protection (PP) engineering SED's relationship to other SEDs is summarized in Figure 1. As shown in Figure 1, PP engineering solutions for the program strongly interact with IA, NCE, and test SEDs.

Relationship to other SEDs

Relationship to IA: Within the global context of IA, PPE applies risk management process to identify, evaluate, rank, and control loss of technology. It is PPE's responsibility to remain cognizant of the program IA effort in meeting the required IA controls and the status of the DIACAP process IAW DoDI 8500.02.

Relationship to NCE: Program protection planning has become significantly more complex as DoD begins to implement Net-centric Operations and Warfare (NCOW) doctrine where basic premise is that program data is developed for sharing with the warfighter in near real-time. This is contrary to the legacy view where access to data is granted with stringent item-by-item qualification process and controls that may lead to loss of timeliness of information. It is PPE's responsibility to be cognizant of the computing and network environment and the data model for the program. Interoperable environments require robust and pervasive network level IA to assure Warfighter's data availability, integrity, and confidentiality.

Relationship to T&E: As part of the PP planning and implementation, anti-tamper are identified, demonstrated, and verified. V&V activities should be integrated with the overall test and evaluation plan for the program.

Tools Selection & Use

The PPP Engineer considers effectiveness and efficiencies gained by selecting and using the best choice of PPP tools considering the PPP tool requirements for program protection, program security, information sharing, automated data exchanges with other tools, and other considerations.

PP Functions Requiring Tools
Technology assessment tools
Trade studies and analysis of PP/AT technology products
Requirements Analyses & Allocations
System Security engineering tools
PP/AT technology V&V and Operational testing

Engineering Activities and Products over the Life Cycle

The Acquisition Program Baseline (APB) includes costs related to PPP implementation.

1. **Materiel Solution Analysis.** During this phase the PPE provides inputs to and supports the JCIDS process. Before contract award, PPE helps identify CPI, foreign involvement, RTP needs and costs, AT needs and cost, and initiates DIACAP assessment.

MSA Phase – Technical Products Required	
SMC PP Technical Products	**PP Contributions to Other Organizations**
Identify CPI	PPP, APB
Identify foreign involvement	DIACAP Package
Identify RTP needs and cost	
Identify AT techniques	
DIACAP assessment	

2. **Technology Development.** During this phase the PPE continues to provide inputs to and supports the JCIDS process.

TD Phase – Technical Products Required	
SMC PP Technical Products	**PP Contributions to Other Organizations**
Update CPI	PPP, APB
Update foreign involvement	DIACAP Package
Update RTP needs and cost	
Update AT techniques	
CI analysis and vulnerabilities	
Initiate CI, TA/CP, AT plans	
Initiate SCG, SSMP	
DIACAP assessment	

3. **Engineering & Manufacturing Development.**) PPE continues to update the PPP and provide inputs to and supports the JCIDS process.

The PPE helps develop the Anti-Tamper V&V plan for review and approval by the DoD Anti-Tamper Executive Agent (ATEA). At Milestone C, validated results are reported to the Milestone Decision Authority.

TD Phase – Technical Products Required	
SMC PP Technical Products	**PP Contributions to Other Organizations**
Update CPI	PPP, APB
Update CI, TA/CP, AT plans	PPP, DIACAP Package
Update SCG	
Update SSMP	
AT V&V plan	
DIACAP Package	

4. **Production & Deployment, Operations & Support.** PPE continues to provide inputs to and supports the JCIDS process.

P&D / O&S Phase – Technical Products Required	
SMC PP Technical Products	**PP Contributions to Other Organizations**
Periodic CPI reassessment	PPP
DIACAP Package	DIACAP Package

PPEs' Contributions to Program and Project Management

Each SMC program defines their business model and approach based primarily on program objectives, technical challenges, organizational structure, and required engineering planning including PP for cost-effective execution.

After completing the protection planning process, the PPE assists the program manager in implementation of countermeasures to protect the CPI at each location and activity identified in the protection planning process. If appropriate, PPE helps the program manager to outsource PP and helps develop RFP/SOW for the contract. That contract activity may include initial program and system evaluation as well as program protection planning that leads to specific Research and Technology Protection countermeasures. Early planning is necessary to ensure that funds are programmed and budgeted to provide timely required contract support.

PPE is responsible for early coordination of the RTP on behalf of the program manager and the contracting personnel to ensure documents contain essential protection requirements. The expected range of protection requirements and projected resources required should be estimated to ensure research and acquisition planning documents address RTP.

Appendix M – Survivability Engineering

A sound survivability program is conducted during all phases of acquisition to ensure that space systems can survive and operate under benign and hostile battlefield conditions including nuclear, chemical, biological, conventional, blast and fragmentation, radiological, electromagnetic, and natural environments. Survivability also enables rapid restoration of the system, subsystem, component, or equipment to improve sustainability of the war-fighting operations. Survivability engineering and management, accomplished early in the acquisition phase, influences the selection of the preferred concept, technologies, and the eventual design and identifies additional support resources required to maintain system readiness. Both manmade and natural causes must be factored into survivable system development, design, and operation. Hence, the SMC Program Office Survivability Engineer supports the full range of concept development, requirements development, engineering analyses and trades, system design and system survivability verification and validation.

The Program Office survivability program also pursues survivability related technology advancement leveraging research facilities, organizations, and projects. For example, the survivability program leverages radiation-hard electronics technologies and industrial base information through the DoD Radiation Hardened Oversight Council (RHOC) as well as commercial sector manufacturers, government labs, and other government agencies. Survivability is the capability of a system to operate without degraded performance if exposed to adverse natural and/or hostile environments. System survivability extends to include the personnel and their interactions essential to operate the system, usually relevant to ground segments. Survivability and force protection KPPs generally apply to SMC ground systems and missions that rely on human interaction to protect and safeguard the warfighter. System survivability is also extended to a system's supporting infrastructure (facilities, basing, subsystems, etc.) and other interfacing systems. AFSPC requires all new space acquisitions to address space protection requirements (including survivability) as KPPs or Key System Attributes (KSAs), where appropriate.

These requirements are to be based on system specific validated threats and vulnerabilities. Comprehensive analysis of threat, impact of loss, countermeasures, and cost are required to determine how the KPPs or KSAs are correlated to the protection of the space, link, ground infrastructure, or cyber system components. The Personnel Survivability and Force Protection are mandatory Key Performance Parameters (KPPs) generally applicable to ground systems. JCIDS Manual, enclosure B, para 2a, 31 Jan 2011 update states "[survivability] includes attributes such as speed, maneuverability, detectability, and countermeasures that reduce a system's likelihood of being engaged by hostile fire, as well as attributes such as armor and redundancy of critical components that reduce the system's vulnerability if it is hit by hostile fire." This aspect of survivability is addressed by in the HSI SED.

This SED describes essential tasks and products, based on current mandates, policy, and practices, for the Survivability Engineer. The Program Office Survivability Engineer plans and performs the essential engineering and management efforts to ensure that the resulting survivability contributions are timely, adequate, consistent, and compliant with the military need.

Applicable governance, standards, and guidance

Table 18 below identifies the significant governance, standards, and guidance, which generally requires SMC compliance for Survivability.

CJCSI 3170.01 requires consideration of survivability as a part of the operational effectiveness that need to be incorporated in the CDD, CPD, or ORD addressing Survivability KPPs. DODD 5000.01 requires that acquisition of systems apply a total systems approach to optimize system performance, operational effectiveness, suitability, survivability, safety, and affordability. DODI 5000.02 requires systems and personnel survivability compliance with chemical, biological, radiological, and nuclear survivability requirements at Milestones B and C. 5000.02 also instructs that the Program Manager or his designee (Survivability Engineer) address personnel survivability issues including protection against fratricide, detection, and instantaneous, cumulative, and residual nuclear, biological, and chemical effects; personnel survivability against asymmetric threats. The PM is required to address special equipment or gear needed to sustain crew operations in the operational environment, including the suitability of equipment intended to enhance personnel survivability against asymmetric threats.

DoDI 3222.3 stands up a DoD level Electromagnetic Environmental Effects (E3) program to develop a survivability criteria. DODI 3150.09 and DODD S-5210.81 require SMC programs to address chemical, biological, radiological, nuclear (CBRN) survivability for SVs, usually as a KPP or KSA (JCIDS Manual, Jan 31, 2011, Appendix A, Enclosure H). AFI 63-101 defines system survivability and sets up roles and responsibilities to meet mandated requirements to include implementation of a hardness assurance, maintenance, and surveillance (HAMS) program IAW DNA-H-93-140, Military Handbook for Hardness Assurance, Maintenance, and Surveillance (HAMS).

SMC standard, SMC-S-014, provides SMC requirements for contractor performance in defense system acquisitions and technology developments for survivability program management for space.

Table 18 Governance, standards, and guidance that shape the Survivability Engineering discipline

Document No	Governance Title	Issue
Public Law 108-375 Sec 141	Development of Deployable Systems to Include Consideration of Force Protection in Asymmetric Threat Environment	28 Oct 04
Public Law 108-375 Sec 1053	Survivability of Critical Systems Exposed to Chemical and Biological Contamination	28 Oct 04
50 USC Section 1522	Conduct of Chemical and Biological Defense Program (CBDP)	
CJCSI 3170	Joint Capabilities Integration and Development System	01 Mar 09
DoDD 5000.01	Defense Acquisition System	20 Nov 07
DoDI 5000.02	Operation of the Defense Acquisition System	08 Dec 08
DoDD 3222.3	DOD Electromagnetic Environmental Effects (E3) Program	
DoDI 3150.09	The Chemical, Biological, Radiological, Nuclear (CBRN) Survivability Policy"	17 Sep 08
DoDD S-5210.81	United States Nuclear Weapons Command and Control, Safety, and Security	18 Aug 05
Stratcom Instr 534-18	Space Survivability Levels (SSL) Classified SECRET/NOFORN	
AFI 63-101	Acquisition and Sustainment Life Cycle Management	22 Mar 11
AFSPCI62-201	Hardness maint/hardness surveillance prog for Survivability of AFSC Systems	02 Feb 98

Document No	Standards Title	Issue
MIL-STD-461F	Electromagnetic Emissions and Susceptibility, Requirements for the Control of Electromagnetic Interference	10 Dec 07
SMC-S-008	Electromagnetic Compatibility Requirements For Space Equipment And Systems	13 June 08
SMC-S-009	Parts Materials and Processes Control Program	12 Jan 09
SMC-S-010	Technical Requirements for Electronic Parts, Materials, and Processes For Space and Launch Vehicles	12 Jan 09
SMC-S-014	Survivability Program Management for Space	19 July 10
Document No	**Guidance Title**	**Issue**
MIL-HDBK-1799	Survivability Aeronautical Systems	14 Feb 97
JCIDS Manual	Manual for the Operation of the Joint Capabilities Integ and Development System	31 Jan 11
MIL-HDBK-237D	Electromagnetic Environ Effects & Spectrum Mgt Guidance for Acquisition Process	20 May 05
HDBK DNA-H-93-140	Military Handbook for Hardness Assurance, Maintenance, and Surveillance (HAMS)	01 Feb 95
MIL-HDBK-279	Total Dose Hardness Assurance Guidelines for Semiconductor Devices and Microcircuits	24 JAN 89
MIL-HDBK-423	High-Altitude Electromagnetic Pulse (HEMP) Protection for Fixed and Transportable Ground-Based Facilities, volume 1, Fixed Facilities	15 May 93
MIL-HDBK-814	Ionizing Dose and Neutron Hardness Assurance Guidelines for Microcircuits and Semiconductor Devices	08 Feb 94
MIL-HDBK-815	Dose Rate Hardness Assurance Guidelines 7 Nov 94, Notice 1 10 Jan 2002, and Notice 2	13 Nov 06
MIL-HDBK-816	Guidelines for Developing Radiation Hardness Assurance Device Specifications, 9 Sep 94, Note 1, 8 Apr 2002, Note 2	11 Apr 07
MIL-STD-1809	Space Environment for USAF Space Vehicles	15 Feb 91
MIL STD 188-125 -1	High Altitude Electromagnetic Pulse (HEMP) Protection for Ground Based C4I Facilities Performing Critical Time-Urgent Mission, Part 1: Fixed Facilities	17 Jul 98
MIL STD 188-125-2	High Altitude Electromagnetic Pulse (HEMP) Protection for Ground Based C4I Facilities Performing Critical Time-Urgent Mission, volume 1: Transportable Facilities	03 Mar 99
DTRA-TR-00-39 V2	Radiation Effects Testing Handbook,	01 Aug 01

Survivability Engineers' Contributions to Acquisition Life Cycle Framework

MSA Phase – SMC Acquisition Products
Initial CRBN and E3 analyses
Inputs to ICD, ASP, STAR
Inputs to SEP, TEMP, LCMP, CARD,
Inputs to concept and technology studies, trades

1. **Materiel Solution Analysis.** The Survivability Engineer establishes the need and extent of the chemical, biological, radiological, and nuclear (CRBN) survivability analyses required to meet the relevant KPPs and program KSVs IAW with the JCIDS manual and the references cited therein. The Survivability Engineer also assesses impact of E3 effects and in-orbit space junk and particulates that may adversely affect the system performance. The results are documented in the ICD and other program documents. The Survivability Engineer also supports the operational and system survivability concept development efforts and System Threat Analysis Report (STAR) for the program. The Survivability Engineer supports NASIC and SMC/IN in STAR development by evaluating expected threats and vulnerabilities at the earliest possible phase of acquisition, using a cost-effective combination of analysis, modeling and simulation, and testing. The Survivability Engineer also derives and manages

the system and allocated levels of Space Situational Awareness (SSA) requirements to detect, characterize geo-locate, and report survivability threats against the system. The Survivability Engineer also maintains the overall security of the survivability strategy of the program, contributes to the development of the program's security classification guide, and reviews all of the contractor's and sub contractor's security plans to make sure the program vulnerabilities are adequately protected.

For SMC space programs, a special emphasis is placed on nuclear and EMP survivability of the SVs IAW DODI 3150.09 and DODD S-5210.81. Initial requirements, results, and shortcomings are reported in the ICD and the ASP, if available. Survivability Engineer also provides inputs to the overall Systems Engineering activities to include concept and architecture development, technologies studies, engineering analyses and trades, cost estimates (CARD), solicitation/RFP development for Contractor studies, and proposal evaluation activities as necessary.

TD Phase – SMC Acquisition Products
Inputs to ASP, TDS, DMS
Inputs to Cost Model, CARD Development
Inputs to CDD, STAR
Update to CRBN analyses; Analyses demonstrating survivability KPP compliance
Detailed survivability planning - SVPP; Inputs to SEP, TEMP, LCMP, TEMP, ISP
RFP: Survivability concepts; TRD/spec req'ts & tailoring; SOO objectives; Survivability tasks in PWS, Survivability data req'ts CDRLs & Tailored DIDs

2. **Technology Development.** For MS B, the Survivability Engineer refines the survivability analyses and develops specific survivability requirements that are measureable and testable. CBRN survivability is a requirement of all CBRN mission-critical systems regardless of Acquisition Category. Most SMC programs are mission critical, and as such, the MS B ASP should include the Program Office development plans to ensure an appropriate level of chemical, biological, radiological and nuclear survivability at Initial Operational Capability (IOC). The ASP should also generally describe survivability requirements, if any. The Survivability Engineer also performs the necessary studies and analyses to show that the overall system concept and unfolding design is in compliance with the survivability KPPs and develops related cost estimates. The Survivability Engineer documents survivability shortcomings for management decisions. The results are recorded in the CDD and the ASP to support the MS B decision. The Survivability Engineer manages the development of survivability techniques such as shielding, countermeasures, space situational awareness, and operational procedures to protect the system against threats as defined in the STAR. Survivability Engineer also provides inputs to the overall Systems Engineering activities to include concept and architecture development, technology studies, engineering analyses and trades, requirements development, cost estimates, solicitation/RFP development for Contractor studies, and proposal evaluation activities as necessary.

3. **Engineering & Manufacturing Development.** The Survivability Engineer ensures CBRN survivability requirements are implements and verified. The Survivability Engineer assists to identify any special test and evaluation requirements. In short, the Survivability Engineer (i) incorporates, implements, and validates survivability design solutions based on defined requirements (ii) ensures that the necessary survivability –related technical requirements (TRD) are in compliance, and (iii) supports solicitation/RFP development and proposal evaluation activities to ensure appropriate cost-effective survivability technologies are acquired to meet program objectives. The results are recorded in the Capability Production Document (CPD) and the ASP to support the MSC decision.

EMD Phase – SMC Acquisition Products
Inputs to ASP, TDS, DMS
Inputs to System Cost Model, LC Cost Estimate Update / CARD Development
Inputs to CPD, Updates to STAR
Update to CRBN analyses; Analyses demonstrating survivability KPP compliance
Detailed survivability planning - SVPP; Inputs to SEP, TEMP, LCMP, TEMP, ISP
RFP: Survivability concepts; TRD/spec requirements and tailoring; Objectives in the SOO; Survivability related tasks in PWS, Survivability data requirements products in CDRLs; Data Item Description - tailored

4. **Production & Deployment, Operations & Support.** The Survivability Engineer maintains system's survivability posture throughout its lifecycle.

P&D / O&S Phase – SMC Acquisition Products
Updates to ASP, TDS, DMS
CARD update
RFP: Survivability related tasks in PWS, Survivability data requirements products in CDRLs; Data Item Description - tailored
Final Survivability compliance analyses
Survivability planning inputs to, SEP, LCMP, TEMP

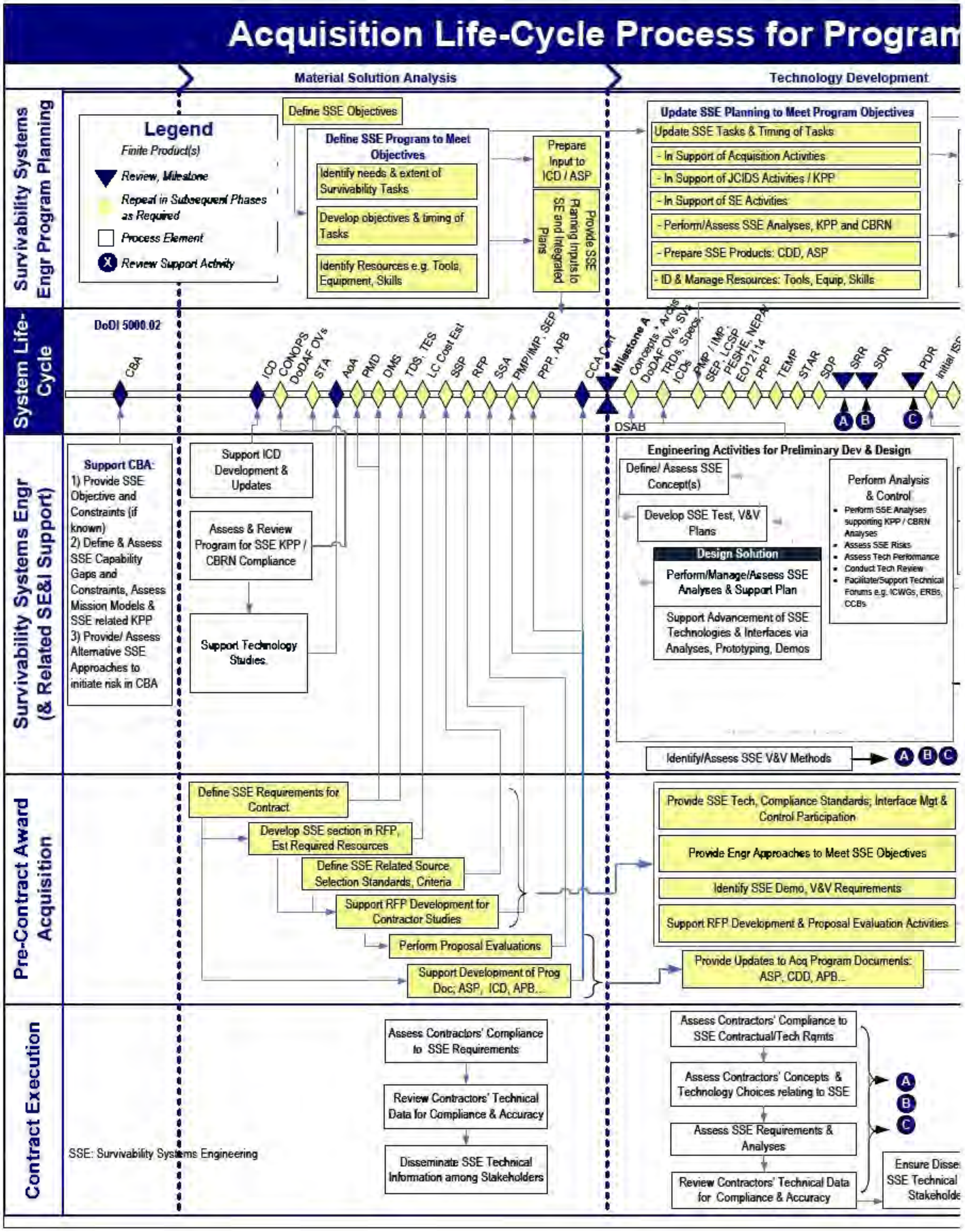
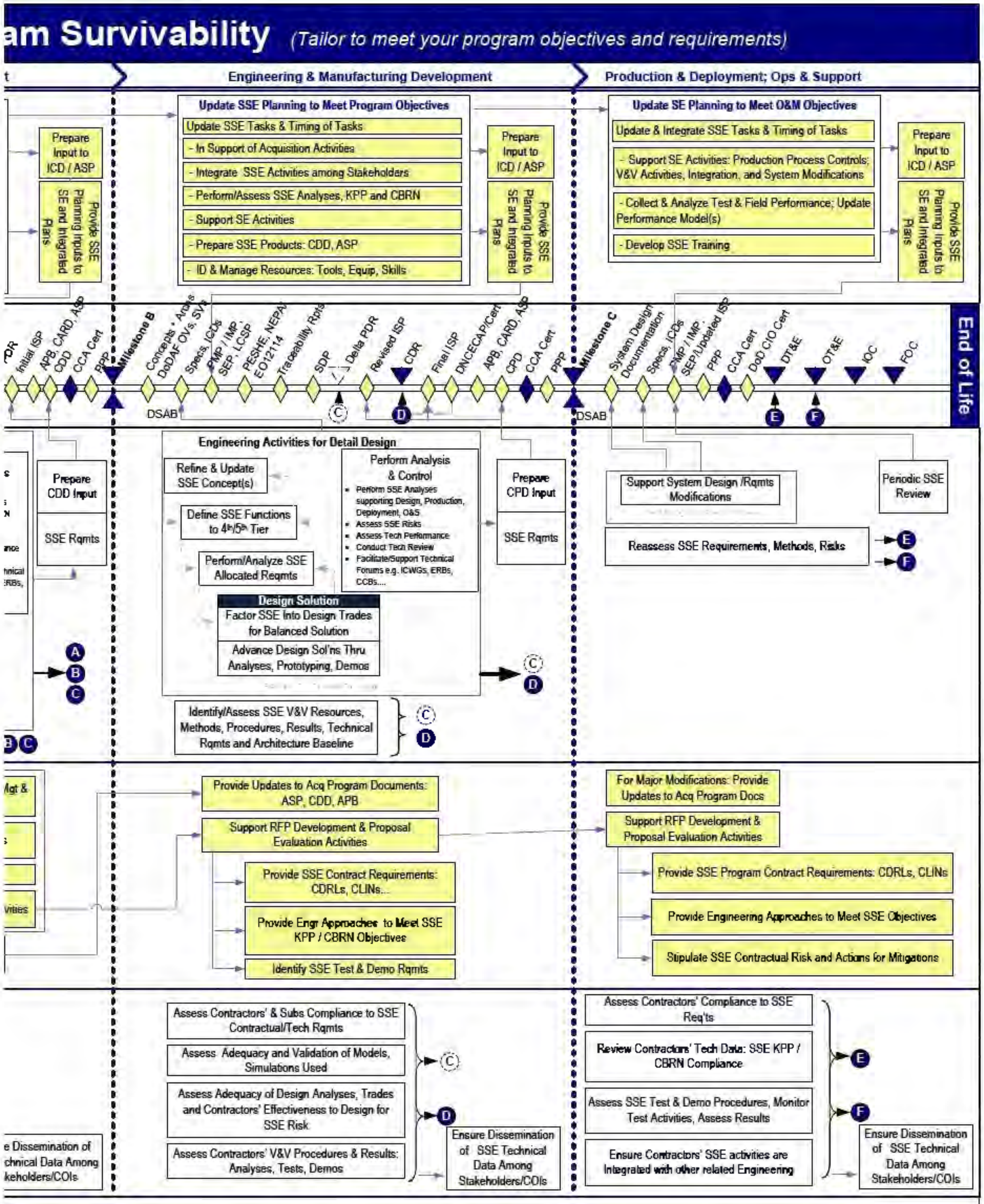


Figure 18 Acquisition life cycle process for SMC Survivability Engineering


am Survivability (Tailor to meet your program objectives and requirements)
Engineering & Manufacturing Development
Production & Deployment; Ops & Support
Update SSE Planning to Meet Program Objectives
Update SSE Tasks & Timing of Tasks
- In Support of Acquisition Activities
- Integrate SSE Activities among Stakeholders
- Perform/Assess SSE Analyses, KPP and CBRN
- Support SE Activities
- Prepare SSE Products: CDD, ASP
- ID & Manage Resources: Tools, Equip, Skills
Prepare Input to ICD / ASP
Provide SSE Planning Inputs to SE and Integrated Plans
Update SE Planning to Meet O&M Objectives
Update & Integrate SSE Tasks & Timing of Tasks
- Support SE Activities: Production Process Controls; V&V Activities, Integration, and System Modifications
- Collect & Analyze Test & Field Performance; Update Performance Model(s)
- Develop SSE Training
End of Life
Milestone B
Milestone C
DSAB
Engineering Activities for Detail Design
Refine & Update SSE Concept(s)
Define SSE Functions to 4th/5th Tier
Perform/Analyze SSE Allocated Reqmts
Perform Analysis & Control
Design Solution
Factor SSE Into Design Trades for Balanced Solution
Advance Design Sol'ns Thru Analyses, Prototyping, Demos
Prepare CDD Input
SSE Rqmts
Prepare CPD Input
Identify/Assess SSE V&V Resources, Methods, Procedures, Results, Technical Rqmts and Architecture Baseline
Support System Design /Rqmts Modifications
Periodic SSE Review
Reassess SSE Requirements, Methods, Risks
Provide Updates to Acq Program Documents: ASP, CDD, APB
Support RFP Development & Proposal Evaluation Activities
Provide SSE Contract Requirements: CDRLs, CLINs...
Provide Engr Approaches to Meet SSE KPP / CBRN Objectives
Identify SSE Test & Demo Rqmts
For Major Modifications: Provide Updates to Acq Program Docs
Provide SSE Program Contract Requirements: CDRLs, CLINs
Provide Engineering Approaches to Meet SSE Objectives
Stipulate SSE Contractual Risk and Actions for Mitigations
Assess Contractors' & Subs Compliance to SSE Contractual/Tech Rqmts
Assess Adequacy and Validation of Models, Simulations Used
Assess Adequacy of Design Analyses, Trades and Contractors' Effectiveness to Design for SSE Risk
Assess Contractors' V&V Procedures & Results: Analyses, Tests, Demos
Ensure Dissemination of SSE Technical Data Among Stakeholders/COIs
Assess Contractors' Compliance to SSE Req'ts
Review Contractors' Tech Data: SSE KPP / CBRN Compliance
Assess SSE Test & Demo Procedures, Monitor Test Activities, Assess Results
Ensure Contractors' SSE activities are Integrated with other related Engineering

Survivability Engineers' Contributions to Engineering Life Cycle Framework

Relationship to SE Organization

The Survivability Engineer plans and executes essential survivability engineering and management efforts in an integrated and effective manner within the context and full support of the overarching Systems Engineering function. The Survivability Engineer ensures that each survivability contribution is timely, adequate, consistent, and compliant. The Survivability Engineer ensures that their contributions are channeled through the Systems Engineering *Analyses and Control* activity.

Systems Engineers manage the engineering process and activities depicted in Figure 3 while the Survivability Engineer contributes to this process by performing, managing, and supporting the concept development effort through the use of modeling and simulation, analyses; concept/architectural/design trades; and technology studies. The Survivability Engineer contributes to the Systems Engineering process and supports technical and program management activities by supporting decision making. The Survivability Engineer contributes to concept and architecture development and analyses; evaluation of survivability technology, and design solutions; modeling and simulation efforts; survivability requirements development; survivability analyses; and verification and validation activities. The Survivability Engineer ensures survivability technical requirements and information are current and commensurate with program maturity and is appropriately applied through systematic control, collaboration, and sharing across the organization to integrate with all SE engineering functions through the system lifecycle. This includes implementation of mandated survivability KPPs and CBRN requirements, as appropriate to the system.

Relationship to other SEDs

Survivability Engineer works closely with T&E Engineer as survivability testing is a key part of the overall T&E strategy, which is designed to provide information on risk and risk mitigation and determines whether systems are operationally effective, suitable, and survivable for the intended use. Modeling and simulation (M&S) techniques are applied, as appropriate, in support of survivability acquisition activities. For example, M&S is essential to determine the total radiation dose that a spacecraft is exposed to in a particular orbit for both the natural environment and possibly the manmade altered environment after a high altitude nuclear detonation (HAND) event. After the exposure characteristics are understood additional extensive modeling is required to determine the dose that radiation-sensitive electronic parts actually accumulate when protected or shielded by the various parts of the spacecraft. Survivability-associated M&S is used as tools in technology areas to support conceptual analysis, technology development, acquisition, testing, fielding, sustainment, operational effectiveness, training, and planned product improvement.

Personnel survivability is addressed by both the Survivability Engineer and the HSI. Personnel survivability is particularly applicable to the SMC Programs' user and ground control segments, and is closely associated with the HSI activities. The Survivability Engineer and HSI collaborate to produce designs as well as operations, and sustainment procedures that protect against known threats and mitigate risk to the warfighter.

The Program Protection Planning (PPP) and Information Assurance (IA) specialties develop the Critical Program Information (CPI) that traditionally relates to protection of technology for warfighter advantage to include Anti-Tamper and Anti-spoof for increased availability of mission critical systems. IA provides security of data at rest and in transport and helps protect against cyber attacks including denial of service. Both PPP and

IA are critical to long term and extended survivability and availability of mission critical systems. The Survivability Engineer closely coordinates with and contributes concepts, analyses, and data on survivability with these disciplines.

Survivability of systems strongly depends on the appropriate choice of parts, materials, and processing and collaborates with the PMP Engineer. For example, radiation hardening is necessary for all parts and materials deployed in space. The Survivability Engineer contributes to the PMP Engineer activities by providing survivability analyses and testing to help make appropriate choices. For further discussion see SMC-S-009 and SMC-S-010.

Other important system engineering disciplines to which Survivability Engineer contributes include Architecture Development, Design Engineering, Reliability, and Maintainability. For ground and space systems, architecture, design, reliability and maintainability are key contributors to a cost-effective strategy for survivability at every stage of development.

Tools Selection & Use

The Survivability Engineer considers effectiveness and efficiencies gained by selecting and using the best choice of survivability designs, strategies and mitigation technology to meet mission critical requirements, including survivability KPPs.

Survivability Functions Requiring Tools
Architecture and design modeling; Modeling and simulation tools
Trade studies and analysis of survivability technology, techniques, and designs
Requirements Analyses & Allocations
Survivability V&V

Engineering Activities and Products over the Life Cycle

The following subsections delineate Survivability Engineer contributions to engineering activities and technical products by DOD acquisition phase.

1. **Materiel Solution Analysis.** Specifically, the Survivability Engineer provides inputs to and supports (i) Breakdown of system components to determine the critical segment that need to survive to be able to meet the overall mission KPP requirements. identification of mission criticality of program, (ii) survivability analyses, (iii) survivability threat assessment, (iv) define the testing process to verify survivability KPP compliance, and (v) CRBN requirements.

MSA Phase – Technical Products Required	
SMC Survivability Technical Products	**Contributions to Other Organizations' Products**
Initial CRBN analyses/ requirements for analysis	Inputs to CBA, ICD; threat assessments
Architecture inputs and survivability factors for concept, architecture, technology studies, and trades; CVs, OVs	Inputs to AoA Studies; Technology Roadmap
Inputs to enabling concepts	Inputs to operational concepts

2. **Technology Development.** The Survivability Engineer continues to provide inputs and supports the JCIDS process. The Survivability Engineer also supports all engineering activities to update and refine survivability analyses and requirements described within the MSA phase.

TD Phase - Technical Products Required	
SMC Survivability Technical Products	**Contributions to Other Organizations' Products**
Update CRBN analyses report	Inputs to CDD; STAR
Hardness analyses requirements, allocations, and design margins	Inputs to AoA Studies, Technology Roadmap
Inputs and survivability factors for concept, architecture, technology studies, and trades; CVs, OVs, SVs, SvcVs, StdVs, AVs,	Inputs to operational concepts
Inputs to enabling concepts	Inputs Technology Roadmap
Inputs to technology studies	

The Survivability Engineer also supports the concept and technology development activities highlighted within the box titled Engineering Activities for System & Segment Development & Design Figure 18 to commence system definition and development. The Survivability Engineer contributes to development of technology roadmaps, avoiding use of high risk, immature technologies that potentially impact system survivability, and system trades and analyses.

The Survivability Engineer performs threat assessments or assesses the adequacy of the assessments for each design concept to identify, analyze threats, viable solutions and determine design margin. The Survivability Engineer ensures the Contractor STAR is compatible with the Government STAR. The Survivability Engineer ensures hardness analyses are performed and adequate to determine hardness requirements, hardness allocations, and hardness design margins. Survivability Engineer considers hardness surveillance and maintenance for ground systems. As applicable, the Survivability Engineer plans and implements a hardness assurance, maintenance, and surveillance (HAMS) program. Survivability Engineer also ensures Contractor the Survivability and Vulnerability Program Plan (SVPP) adequately documents survivability engineering management and technical approaches essential for the cost-effective development of a survivable system.

The Survivability Engineer contributes to the development of TD Phase technical products with emphasis on enabling and critical technologies. The Survivability Engineer also provides inputs to the RFP, PWS, TDS, SEP, and CARD that includes (i) derivations and allocations of the KPP/KSA requirements to the TRD/ specification, (ii) technical considerations for choosing survivable design characteristics and solutions, (iii) solution implementation schedule, (iv) cost, (v) funding profile, and (vi) staffing and support requirements.

3. **Engineering & Manufacturing Development.** The Survivability Engineer continues to provide inputs to and supports the JCIDS process. The Survivability Engineer (i) supports engineering activities to further develop, refine, or modify the survivability solutions of the system architecture and system requirements, (ii) ensures the survivability solutions are compliant with survivability KPPs, (iii) supports studies, trades and decision processes, (iv) refines CRBN technical requirements, analyses and provides proposed solutions, (v) supports development of IA/IA-

EMD Phase - Technical Products Required	
SMC Survivability Technical Products	**Contributions to Other Organizations' Products**
Update CRBN analyses report	Inputs to CPD; STAR
Inputs and survivability factors for concept, architecture, technology studies, and design trades; CVs, OVs, SVs, SvcVs, StdVs, AVs,	Inputs to operations procedures
Inputs to system design, production, fielding, sustain docs	

enabled products, (v) helps determine and implement survivability technology insertion and solutions, (vi) assists to arrange and schedule specialized testing facilities, (vii) supports RFP development and source selection activities, and (viii) continues to support technical solutions trades to ensure compliance with survivability mandates (KPPs, CBRN). The Survivability Engineer also works closely with the SEs and other specialty engineers in performing interface analyses, functional analyses, and the integration and verification and validation planning and execution, and conducts survivability training. The Survivability Engineer ensures adequacy of hardness assurance characterization testing (development) and lot acceptance testing (production).

4. **Production & Deployment, Operations & Support.** Survivability Engineer continues to provide inputs to and supports the JCIDS process. During the production phase, the Survivability Engineer helps ensure the parts produced are adequately hardened. The Survivability Engineer reviews and approves the contractor's survivability-related test procedures and verifies that they are in compliance with the test plans and the design specifications. Following each survivability-related test, the Survivability Engineer verifies that the test results and test report show that the system adequately met the survivability requirements. Survivability Engineer continues to review revisions of STAR and intelligence reports of new threats for possible impact to the system. If on-orbit operational anomalies occur, the Survivability Engineer reviews the impact of the anomalies for potential new vulnerabilities and evaluates strategies to mitigate those threats, and if actual attacks are made against the system, the impact of the threats against the existing design needs to be determined and design changes evaluated to reduce the risk to the mission due to those threats.

P&D / O&S Phase - Technical Products Required	
SMC Survivability Technical Products	**Contributions to Other Organizations' Products**
Periodic re-assessment of system survivability	Supportability Analyses Rpt
Inputs tech baseline eng changes	
Inputs to Transition & Field Docs	

Survivability Engineer Contributions to Program and Project Management

Each SMC program defines their business model and approach based primarily on program objectives, technical challenges, organizational structure, and required engineering planning including survivability for cost-effective execution.

The Survivability Engineer helps the Program Manager to fully integrate resources and skills that lead toward the intended system survivability against all anticipated threats at all levels of conflict early in the program, usually before entering production. Survivability Engineer ensures that M&S, T&E, and HSI and other specialty engineers are involved in the decision making process to implement survivability mandates to mitigate risk to the warfighter and system.

SMC Program Management Products
ASP, ICD, CDD, CPD, STAR
Decision-making & problem solving inputs
Cost Estimate (CARDs)
PWS, RFP , SRD, TRD, Source Selection
Developmental and Operational tests
Threat Assessment and Risk Management Inputs

The Survivability Engineer further assists the Program Manager to ensure CBRN survivability for all mission critical systems IAW DoDI 3150.09, whose operating environment would include operating in a CBRN environment according to STAR or Capstone Threat Document. Cost-effective survivability techniques and a plan for the validation and confirmation of CBRN survivability should be developed.

The Survivability Engineer manages the survivability program throughout the system life cycle to attain overall program objectives, stressing early investment to provide a balanced survivability approach that balancing overall survivability requirements with other design characteristics and program cost, schedule and performance requirements enhancing mission effectiveness and operational readiness requirements by:

- Incorporating design features to prevent or reduce engagement of threat weapons
- Providing mission planning and dynamic situational awareness features to enable tactical threat avoidance
- Incorporating vulnerability reduction features including design redundancy

The Survivability Engineer verifies that the performance work statement (PWS) and technical requirements document (TRD) in the RFP accurately reflect the requirements in the CDD, and that the survivability-related requirements in sections L and M will allow the Government to adequately evaluate the contractor's capability to meet those survivability requirements. During the actual source selections or down-selects, the Survivability Engineer will evaluate the contractor's proposals and make the necessary recommendations to the Source Selection Evaluation Board (SSEB) and Space Situational Awareness (SSA) concerning the adequacy of the contractor's proposed approach to meet survivability requirements.

The Survivability Engineer develops and implements the survivability program planning to achieve the required objectives and requirements. The planning defines the survivability related tasks and functions to be performed; products to be developed; and timing of tasks, task outputs, resources (skills, tools, equipment, and completion criteria). The Survivability Engineer plans tasks to integrate survivability activities within the Program Office, between contractors, and community stakeholders. The Survivability Engineer plans the tasks to establish and manage survivability activities, support SE&I activities, e.g., system technical solutions trades and analyses risk management, integration, and system modifications; coordinate the survivability planning with Systems Engineering, operating commands, supporting commands, and test agencies; and integrate the planning with other functional and acquisition plans (i.e. SEP, ASP, LCMP).

Execution of the survivability planning is typically defined through an Operating Instruction (OI). The Survivability Engineer provides full support to define the program and technical objectives where concept and architectural challenges and risks are known or anticipated. The Survivability Engineer ensures the concept development and management components of the program are appropriately represented in the program plans, program schedules, work breakdown schedules, and cost estimates. The Survivability Engineer reports their technical performance and progress. The Survivability Engineer shares in the risk management responsibilities to identify, assess, and propose mitigating actions of their related risks. Survivability Engineer also supports the Program Manager's problem identification, resolution, and decision-making processes.

Appendix N – Human Systems Integration

Within the Department of Defense's acquisition lifecycle framework, systems engineering and program management activities, Human Systems Integration (HSI) is a vital component in the DoD's total system approach.

Human Factors Engineering (HFE) is the engineering application of the knowledge of human capabilities and limitations with respect to system or equipment design, development, operations, and sustainment. Its objective is to maximize efficiencies, effectiveness, and safe system performance, while minimizing cost, manpower, skills and training resources. HSI is a comprehensive management and technical strategy to ensure human performance factors are continuously addressed throughout the system life cycle.

When human systems integration is a significant factor, the SMC program office establishes and designates authority responsible for managing and executing the HSI program. Its responsibilities include planning, supervising and ensuring essential HSI and management efforts are integrated with the various acquisitions, management, & engineering processes. It ensures effectiveness and compliancy to the assorted policies, DoD mandates, instructions, and SMC acquisition program and technical objectives, as it pertains to the implementation of HSI program strategies and plans.

Applicable governance, standards, and guidance

HSI is an integral part of numerous mandates including public law, policies, directives, and instructions. It is a Systems Engineering Discipline (SED) that is associated with multiple functional disciplines within the Systems Engineering realm including acquisition, information assurance, systems engineering, software engineering, test and evaluation and others. Table 19 below identifies the significant governance which generally requires SMC compliance for HSI.

Table 19 Governance, standards, and guidance that shape the Human Systems Integration discipline

Document No	Governance Title	Issue
Public Law 110-181, Section 231	National Defense Authorization Act (NDAA) 2008, OSD HSI Management Plan	28 Jan 08
DoDD 1100.4	Guidance for Manpower Management	12 Feb 05
DoDD 1322.18	Military Training	13 Jan 09
DoDD 5000.01	The Defense Acquisition System	12 May 03
DoDI 1100.22	Policy and Procedures for Determining Workforce Mix	12 Apr 10
DoDI 1322.20	Development and Management of Interactive Courseware (ICW) for Military Training	14 Mar 91
DoDI 5000.02	Operation of the Defense Acquisition System	08 Dec 08
DoDI 6055.1	DoD Safety and Occupational Health (SOH) Program	19 Aug 98
	FY09 DoD Human Systems Integration Management Plan Version 1.0	09
CJCSI 6212.01E	Interoperability and Supportability of Information Technology and National Security Systems	15 Dec 08
AFI 10-601	Operational Capability Requirements Development	12 Jul 10
AFI 10-602	Determining Mission Capability & Supportability Requirements	18 Mar 05
AFI 63-1201	Life Cycle Systems Engineering	23 Jul 07
AFHSIO Strategy	AF HSI Office Strategy	Dec 08

	AF FY09 Human Systems Integration Management Plan (Annex to the OSD HSI Management Plan)	09
Document No	**Standard Title**	**Issue**
MIL-STD-1472F	Department of Defense Design Criteria Standard: Human Engineering	23 Aug 99
MIL-STD-1908B	Definitions of Human Factors Terms	16 Aug 99
SMC-S-023	Human Computer Interface Design Criteria Vol I: User Interface Requirements	19 Mar 10
SMC-S-023	Human Computer Interface Design Criteria Vol II: Space System Operations Displays	19 Mar 10
Document No	**Guidance Title**	**Issue**
DAG, Chapter 2, Chapter 6	The Defense Acquisition Guidebook, Human Systems Integration	05 May 10
DoD-HDBK-743A	Anthropometry of U.S. Military Personnel	13 Feb 91
DoD TAFIM, Vol. 8	DoD Technical Architecture Framework for Information Management, Volume 8: DoD Human Computer Interface Style Guide Version 3.0	30 Apr 96
CJCSM 3170.01	Operation of the Joint Capabilities Integration and Development System	01 May 07
MIL-HDBK-759C	Department of Defense Handbook For Human Engineering Design Guidelines	31 Jul 95
MIL-HDBK-761A	Human Engineering Guidelines for Management Information Systems	30 Sep 89
MIL-HDBK-46855A	Human Engineering Program Process and Procedures	17 May 99
AFI 63-101	Acquisition and Sustainment Life Cycle Management	22 Mar 11
EIA-HEB1	Human Engineering – Principles and Practices	Jun 02

When analyzing and evaluating HSI requirements, the HSI manager must fully understand the seven HSI domains, the integration between these domains, as well as the interrelation with core acquisition, engineering and program management processes. This comprehensive integration is the key to a successful HSI strategy and realization. The seven domains of HSI include: 1) Manpower, 2) Personnel, 3) Training, 4) Environment, Safety and Occupational Health (ESOH), 5) Human Factors Engineering, 6) Survivability, and 7) Habitability. A brief description of each of the domains is provided below.

Manpower

Manpower factors ultimately pertain to the number and mix of military and DoD civilian personnel and contract support that is necessary to operate, maintain, support and provide training for the system or equipment. This number is derived from the job tasks, operation/maintenance rates, associated workload and operational conditions of the proposed/awarded contract. In generating the number and mix, DoD Directive 5000.01 mandates program projections of dollars and manpower to be realistic and based upon timely studies and analyses. In the end, the definitive goal is to identify shortfalls that may adversely impact the execution of a program and to determine the most efficient and cost effective number and mix of people required, authorized and available to operate, maintain, support, and provide training for a system or equipment.

Personnel

HSI personnel factors include human aptitude, knowledge, skills, abilities (KSAs), and experience levels required to properly perform job tasks. The purpose of identifying these personnel factors in the acquisition process is to ensure a system or equipment is designed with the target audience in mind and conforms to the capabilities and limitations of a specified user population that is expected to be in place at the time the system is fielded.

Personnel Survivability and Force Protection

Survivability involves a system's ability to withstand man-made or natural hostile environments without aborting the mission, suffering acute chronic illness, disability or death. Survivability and Force Protection are statutory Key Performance Parameters (KPP), applicable to all manned systems. JCIDS Manual, enclosure B, para 2a, 31 Jan 2011 update states "[survivability] includes attributes such as speed, maneuverability, detectability, and countermeasures that reduce a system's likelihood of being engaged by hostile fire, as well as attributes such as armor and redundancy of critical components that reduce the system's vulnerability if it is hit by hostile fire." While survivability addresses manned systems and their ability or hardening against hostile fire, force protection KPP attempts to mitigate hostile actions against friendly personnel, military and civilian, to comply with the congressional direction. Reported in System Threat Analysis Report (STAR), all systems must be assessed for expected threats and vulnerabilities in the earliest possible phase of acquisition using a cost-effective combination of analysis, modeling and simulation, and testing.

Training

This domain refers to the learning process by which personnel individually or collectively acquires or enhances pre-determined job-relevant KSAs by developing their cognitive, physical, sensory, and team dynamic abilities. It also includes "tools" used to provide the learning experiences such as job performance aids, simulators, computer based interactive courseware and electronic manuals, as well as actual equipment. The paramount goal is to develop and sustain a ready, well-trained individual/unit, while strongly heeding options to reduce life-cycle costs.

Human Factors Engineering (HFE)

The concept of HFE is to understand competencies required for a particular job, and to help identify if requirements for KSAs exceed what the user can provide. As a result, it distinguishes deficiencies that will lead to training or operational problems ahead of time. In other words, HFE is primarily concerned with designing human-machine interfaces consistent with the KSAs of the user population.

Safety & Occupational Health (ESOH)

The primary purpose of ESOH is to concentrate on system design features that minimize the potential for mishaps causing death or injury to operators and maintainers or threaten the survival or operation of the systems. It takes into account the conditions in and around the system and the operational context within which the system will be operated and supported (the environment) and its impact on human ability to function as part of the system. In addition, it works toward achieving system design features that serve to minimize the risk of injury, acute or chronic illness, or disability, as well as factors reducing job performance of personnel who operate, maintain, or support the system.

Habitability

The living and working conditions that are necessary to sustain the morale, safety, health, and comfort of the user population are the characteristics of the habitability domain. These factors directly contribute to personnel effectiveness and mission accomplishment, and it is comprised of systems, facilities and services necessary to satisfy personnel needs. It aims to achieve the balance of maximum personnel effectiveness, support mission performance and avoid personnel retention problems.

Human Systems Integration Contributions to the Acquisition Life Cycle Framework

In the modern technology era, systems and equipment have increasingly become more complex and sophisticated. Marketing efforts for these systems highly accentuate new features, technical designs, capabilities and benefits of the systems, but greatly overshadow human elements that play a critical role in its overall success. With respect to the DoD Acquisition Life Cycle, the overall goal is to create optimized total systems performance and lower total ownership costs, which is highly contingent upon the warfighter's ability to use the systems fully and effectively to accomplish the mission. HSI is vital in achieving total system performance while maximizing human capabilities and overcoming human limitations. Figure 19 below exhibits the requirements and products that need to be developed with respect to the acquisition life cycle framework. This graphical representation provides the HSI Manager with a bird's eye view of how HSI fits within the acquisition life cycle framework. It also illustrates the required support for pre and post contract award acquisition activities as well as across the system lifecycle as it pertains to this discipline.

Like most disciplines in the acquisition process, an effective HSI program is instilled in the early planning phases of the acquisition life cycle. The purpose of this planning process is to anticipate challenges and obstacles to overcome in the HSI arena. In the past, a comprehensive HSI process was not instituted as part of the Capabilities Based Planning and Requirements Development to advocate the human aspects of a system design. However, numerous investigative projects in recent years have led to DoD's positioning to mandate HSI into this practice.

In today's budget conscious and time constrained acquisition environment, HSI capabilities need to be addressed early in the entry portion to the JCIDS process otherwise known as the Capabilities Based Assessment (CBA). The results of the CBA are documented in one of two documents. For non-materiel solutions, the output is a joint Doctrine, Organization, Training, Materiel, Leadership & Education, Personnel or Facilities (DOTMLPF) Change Recommendation (DCR). For materiel solutions, an Initial Capabilities Document (ICD) is the preferred means of addressing and documenting CBA results. The CBA incorporates an analysis of all applicable HSI domains that may solve and/or mitigate the capability gaps and the HSI implications of designing, developing, fielding and sustainment. Frequently, the rationale for the recommended solution (materiel or non-materiel) and the reasoning as to why other options are inadequate, infeasible, or undesirable is also documented in the CBA.

Below are the HSI activities and products that are highlighted in each of the respective phases of the Acquisition lifecycle.

MSA Phase – SMC Acquisition Products
PMD, Acquisition Strategy, AoA, APB, SSP, STP
Market Research
ICD
SEP, LCMP
PESHE, HHA
ORD, COEA, IMP, ME

1. **Materiel Solution Analysis.** Many of the critical functions of HSI are front loaded in the process and resident in this phase of the acquisition lifecycle. The primary objectives of this phase of the acquisition lifecycle are to identify areas of potential HSI concerns and to ensure that HSI-related goals, objectives, critical design issues and metrics are addressed. The results of these efforts are used in the early Analysis of

Alternatives (AoAs) to identify Non-Developmental Items (NDIs) and/or Commercial Off The Shelf (COTS) products that are appropriate for the system design. In addition, the findings of the AoA are also incorporated in market research that is conducted to ensure proper identification and representation of HSI requirements.

The SMC HSI Manager must comply with the provisions of DoDI 5000.02, Enclosure 8, and ensure HSI planning is summarized in the Acquisition Strategy and reflected in the Systems Engineering Plan (SEP). In general, the Acquisition Strategy must address HSI issues that adversely impact the program's ability to successfully execute and, ultimately, meet the warfighters needs. It must highlight modifications to the KSAs of military occupational specialties for system operators, maintainers, or support personnel or additional skill indicators, or issues relating to hard-to-fill occupations. It must incorporate a thorough investigation of each of the 7 HSI domains and their relevance to the acquisition. In addition, the Acquisition Strategy must summarize planned steps (e.g., contract deliverables) to ensure HFE is employed during systems engineering throughout the life of the program in order to provide effective human-machine interfaces and meet HFE and other HSI requirements.

As part of the risk assessment section of the Acquisition Strategy, the HSI Manager is required to amalgamate the Manpower Estimate (ME). The ME is used to reflect manpower affordability in terms of military end strength (including force structure and student end strength) and civilian work years beginning at Milestone B. The ME identifies, as risks, the periods when man power increases are required to support a major program or when manpower shortfalls exist. Within the scope of HSI, additional attention is required when fabricating the Life Cycle Sustainment Plan (LCSP). The HSI Manager must summarize plans for survivability and address the risks and mitigation plans in the LCSP. In addition, the HSI Manager needs to also take into account habitability factors and issues that may potentially impact morale, safety, health or comfort, or degrade personnel performance, unit readiness, or result in recruitment or retention problems.

Whether the intent of the acquisition program is to establish a new capability, improve an existing one, or exploit an opportunity to reduce costs or enhance performance, one of the most prominent documents in this phase is the Initial Capabilities Document (ICD), a part of the Joint Capabilities Integration Development System (JCIDS) process. As indicated above, the ICD is the product of a materiel solutions derived from the CBA. The ICD provides a critical medium for discussion on training requirements that is relevant throughout the system's entire acquisition life cycle and the ensuing capabilities documents. The HSI Manager works with AFSPC to ensure that the DOTMLPF section of the ICD describes all of the relevant domains of HSI including the key boundary conditions and operational environments that impact how the system is employed to satisfy the mission need. Key boundary conditions within which the AoA is to be performed include critical manpower, personnel, training, environment, safety, occupational

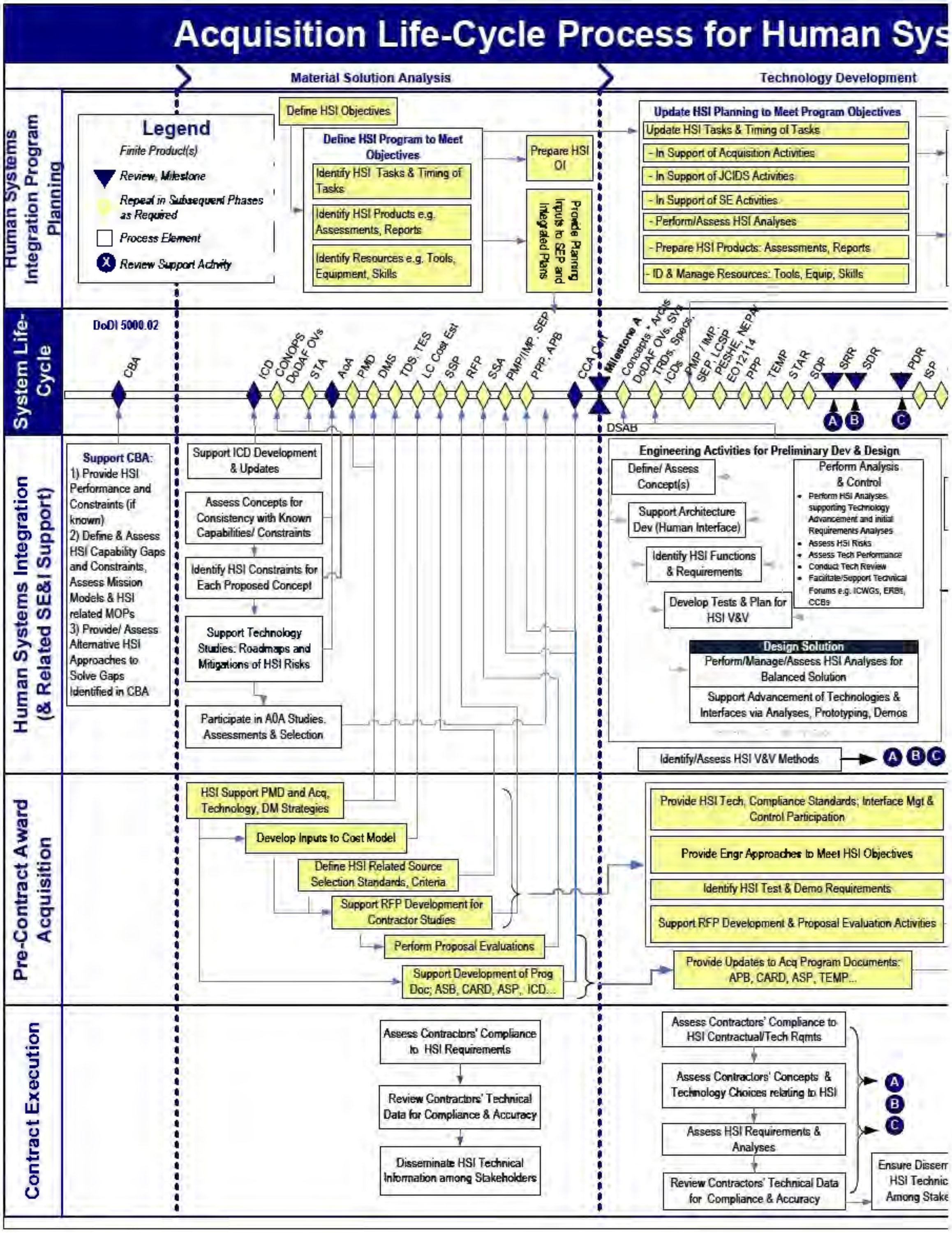
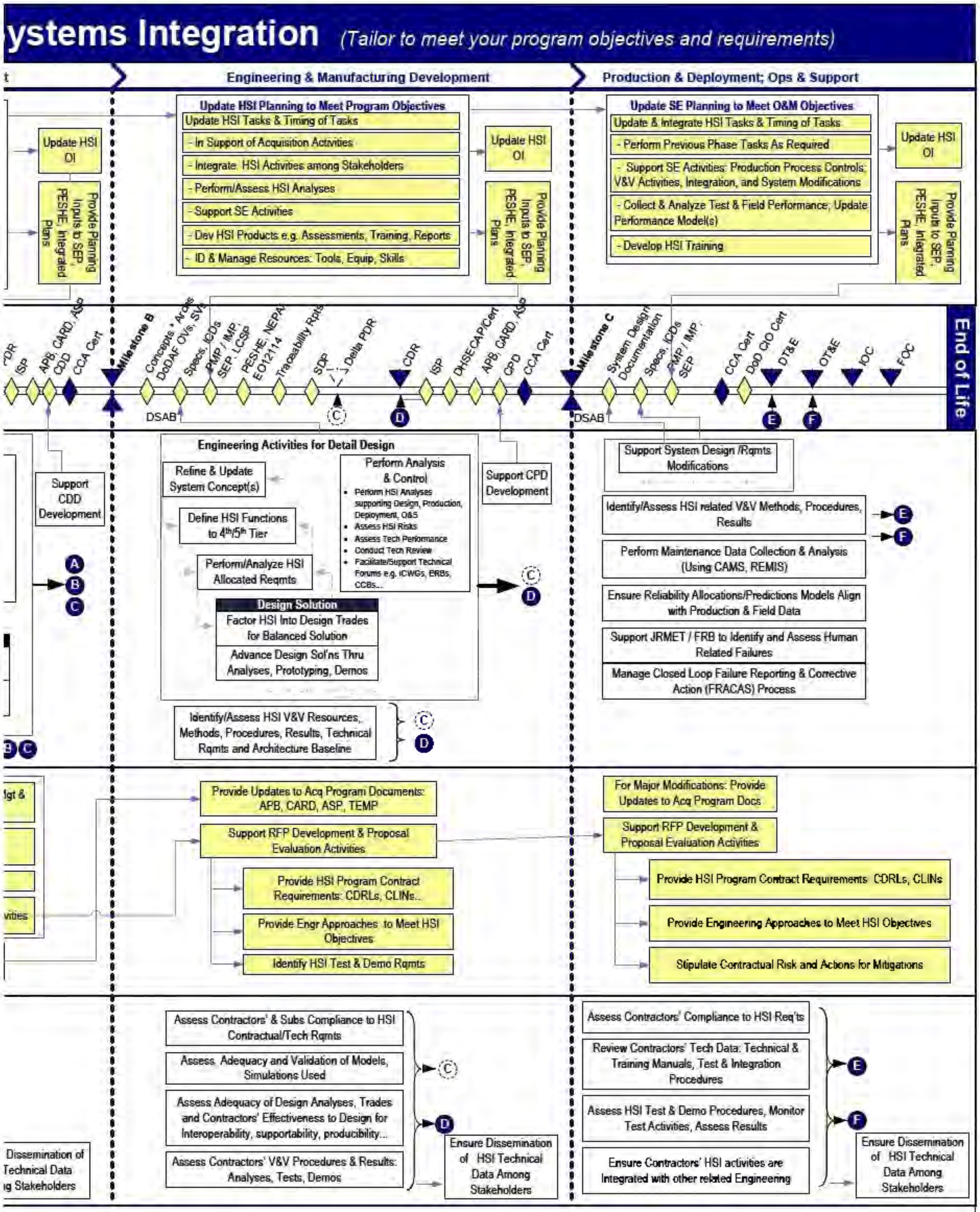


Figure 19 Acquisition life cycle process for SMC Human Systems Integration


ystems Integration (Tailor to meet your program objectives and requirements)
Engineering & Manufacturing Development
Production & Deployment; Ops & Support
Update HSI Planning to Meet Program Objectives
Update HSI Tasks & Timing of Tasks
- In Support of Acquisition Activities
- Integrate HSI Activities among Stakeholders
- Perform/Assess HSI Analyses
- Support SE Activities
- Dev HSI Products e.g. Assessments, Training, Reports
- ID & Manage Resources: Tools, Equip, Skills
Update HSI OI
Provide Planning Inputs to SEP, PESHE, Integrated Plans
Update SE Planning to Meet O&M Objectives
Update & Integrate HSI Tasks & Timing of Tasks
- Perform Previous Phase Tasks As Required
- Support SE Activities: Production Process Controls; V&V Activities, Integration, and System Modifications
- Collect & Analyze Test & Field Performance; Update Performance Model(s)
- Develop HSI Training
End of Life
Milestone B
Milestone C
DSAB
Engineering Activities for Detail Design
Refine & Update System Concept(s)
Define HSI Functions to 4th/5th Tier
Perform/Analyze HSI Allocated Reqmts
Perform Analysis & Control
Design Solution
Factor HSI Into Design Trades for Balanced Solution
Advance Design Sol'ns Thru Analyses, Prototyping, Demos
Support CPD Development
Support CDD Development
Identify/Assess HSI V&V Resources, Methods, Procedures, Results, Technical Rqmts and Architecture Baseline
Support System Design /Rqmts Modifications
Identify/Assess HSI related V&V Methods, Procedures, Results
Perform Maintenance Data Collection & Analysis (Using CAMS, REMIS)
Ensure Reliability Allocations/Predictions Models Align with Production & Field Data
Support JRMET / FRB to Identify and Assess Human Related Failures
Manage Closed Loop Failure Reporting & Corrective Action (FRACAS) Process
Provide Updates to Acq Program Documents: APB, CARD, ASP, TEMP
Support RFP Development & Proposal Evaluation Activities
Provide HSI Program Contract Requirements: CDRLs, CLINs
Provide Engr Approaches to Meet HSI Objectives
Identify HSI Test & Demo Rqmts
For Major Modifications: Provide Updates to Acq Program Docs
Provide Engineering Approaches to Meet HSI Objectives
Stipulate Contractual Risk and Actions for Mitigations
Assess Contractors' & Subs Compliance to HSI Contractual/Tech Rqmts
Assess Adequacy and Validation of Models, Simulations Used
Assess Adequacy of Design Analyses, Trades and Contractors' Effectiveness to Design for Interoperability, supportability, producibility...
Assess Contractors' V&V Procedures & Results: Analyses, Tests, Demos
Ensure Dissemination of HSI Technical Data Among Stakeholders
Assess Contractors' Compliance to HSI Req'ts
Review Contractors' Tech Data: Technical & Training Manuals, Test & Integration Procedures
Assess HSI Test & Demo Procedures, Monitor Test Activities, Assess Results
Ensure Contractors' HSI activities are Integrated with other related Engineering

health, human factors, habitability and survivability factors that have a major impact on a systems performance and life-cycle costs. Additional HSI concepts to be considered include recommendations on the type of materiel approach preferred for each capability gap. In essence, the ICD must include language that baselines HSI considerations for the system acquisition. The MS A Phase – SMC Acquisition Products table exhibits the products that are produced during the Materiel Solution Analysis phase.

2. **Technology Development.** In this phase of the acquisition life cycle, HSI continues to play a critical role in the development of a system and must be discussed in various acquisition documents. One of the primary documents that need to address HSI concerns is the Capability Development Document (CDD). An HSI Manager collaborates with the developers of the CDD and the Program Office Systems Engineers to ensure that the CDD and the system specification of requirements (technical requirements document to be use in the planned acquisition) incorporates important discussions regarding HSI including the specification of human-in-the-loop requirements (e.g., "human in control," "manual override," or "completely autonomous operations." The HSI Manager must also identify operational considerations that affect sensory processes (sensory requirements), as well as applicable survivability parameters, including the requirements to eliminate significant risks of fratricide or detectability, or to be survivable in a chemical, biological, radiological, nuclear (CBRN) battlefield.

TD Phase – SMC Acquisition Products
Updates to ASP, APB
CARD Development
CDD
TEMP, MER
RFP, SOW, SOO, PWS, CDRLs, ACTDs
Detailed HSI planning: SEP, LCMP, TEMP, SSP, STP

The HSI Manager also ensures that the CDD discusses specific system training requirements, the training Key Performance Parameters (KPPs) and additional performance attributes in threshold-objective format. The training must allow interactions between platforms or units (e.g. through advanced simulation and virtual exercises) and provide training realism to include threats (e.g. virtual and surrogate), a realistic electronic warfare environment, communications, and weapons. It must also consider embedded training capabilities that do not degrade system performance below threshold values nor degrade the maintainability or component life of the system. The HSI Manager works closely with the systems engineers to derive the HSI systems specification of requirements from the CDD and known technology, operational, and sustainment constraints.

A summary of DOTMPLF implications associated with fielding the system must be documented in the CDD as well as any capabilities-oriented performance-based HSI requirements that drive design, cost, and/or risk. It must also document attainment of the Initial Operating Capability (IOC) and the training capabilities that are embedded and met by IOC. The CDD also needs to address an embedded performance measurement capability to support immediate feedback to the operators/maintainers and possibly to serve as a readiness measure for the unit commander. Lastly, the CDD must address the training logistics necessary to support the training concept (e.g., requirements for new or upgrades to existing training facilities.)

HSI issues and concerns are also incorporated into the Test & Evaluation Management Plan (TEMP) and related documents (e.g., SEP, LCMP, System Safety Hazard Analysis, System Training Plan and specifications), which eventually translates these requirements to the RFP, SOW and contract documentation. Essentially, this process integrates HSI requirements into the various plans and ensures full consideration has been given throughout the planning process in designing the system.

HSI capabilities must be specified in measurable, testable, performance-based language that is specific to the system and mission performance. The result of setting specific, quantifiable HSI parameters/requirements in the CDD is that it assists in the establishment of test criterion later in the TEMP. As trade-offs are made and plans for the system mature, the CDD and all capabilities and acquisition documents must become more specific and reflect the refinement and integration of program objectives. The table above displays the requisite documentation that is generated throughout the acquisition lifecycle as it relates to HSI.

3. **Engineering & Manufacturing Development.** The purpose of this next phase of the acquisition lifecycle is to develop a system or an increment of capability, develop an affordable and executable manufacturing process, as well as implement human systems integration amongst a host of other critical events. It is during this phase that system design efforts lock in the operations and support costs, which amounts to approximately 60% of the systems overall life cycle costs. Therefore, the HSI Manager needs to employ human factors engineering to design systems that require minimal manpower, provide effective training, can be efficiently operated and used, and meets all of the HSI requirements as specified in DoDI 5000.02 in achieving the overall goal of total optimization and minimized ownership cost.

EMD Phase – SMC Acquisition Products
Updates to ASP, APB
CARD update
CPD
TEMP, SEP, MER
RFP, SOW, SOO, PWS, CDRLs, ORD
Detailed HSI planning: SEP, LCMP, TEMP updates, SSP, STP

As a follow up to the CDD, the HSI Manager must continue to support the inclusion of HSI in another JCIDS capabilities document known as the Capability Production Document (CPD) in this phase. In the CPD, the HSI Manager provides a level of refinement of performance attributes and KPPs validated in the CDD. The HSI assists AFSPC to ensure that the CPD specifies "safe limits" for environment, safety and health hazards, while also providing updates to the CPD regarding KPPs and key system attributes , DOTMLPF implications, and, of course, capabilities-oriented performance-based HSI requirements that are driving design, cost and/or risk.

In summary, the EMD phase is the period in the acquisition process in which potential human related shortfalls and failures in human-machine integration are identified. The HSI Manager is responsible for updating HSI in all program acquisition documentation to include the latest system specifications/technical requirements documents, integration strategy, analyses of training and support requirements, as well as developing, executing and coordinating with program management, mitigation strategies for those shortfalls and failures.

4. **Production & Deployment, Operations & Support.** In the PD phase, the primary objective as it pertains to HSI is to ensure that the production version of the system continues to meet the human performance criteria established and tested during the EMD phase. This is predominantly accomplished through Test & Evaluation (T&E) and demonstration efforts, which verifies the user-system interface and procedures are properly designed so that the system can be operated, maintained, supported and controlled in its intended operational environment by typical users.

P&D / O&S Phase – SMC Acquisition Products
Updates to ASP
CARD Update
MER
Detailed planning: SEP, LCMP, TEMP, SSP, STP updates

The main objective of the OS phase is to execute a support program that meets operational support performance requirements and sustains the system in the most cost-effective manner over its total life cycle. As previously stated, approximately 60% of a system's total costs are generated during this phase. In an effort to obtain total system optimization and the most cost-effective solutions, it is ever more critical to heed HSI considerations particularly in designing effective system modifications to include training, supportability, interoperability and maintenance functions. Obviously, the lack of appropriate HSI involvement in the design can result in system shortcomings that require costly redesign, produce substandard system performance and potentially precipitate system failures endangering life and equipment.

HSI's Contributions to the Engineering Life Cycle

Relationship to the SE Organization

HSI is included as a vital process within systems engineering and must be implemented throughout the systems engineering life cycle to "balance total system performance (hardware, software and human), Operational Safety, Suitability & Effectiveness (OSS&E) assurance, survivability, safety and affordability." Throughout the systems engineering process, technical analyses are constantly performed iteratively to define successively lower functional and performance requirements. The goal is to identify functional interfaces and to allocate functions to components of the system (e.g., hardware, software and human). Similarly, requirements analyses are conducted iteratively in conjunction with logical analysis to develop and refine system level performance requirements, identify external interfaces, and provide traceability among user requirements and design requirements. With respect to HSI and the systems engineering process, human-machine interfaces must be identified as part of this functional allocation process.

An HSI Engineer must ensure the Critical Operational Issues (COIs), Measures of Effectiveness (MOEs), and Measures of Performance (MOPs) are constantly addressed throughout the engineering life cycle. More importantly, the HSI Engineer needs to be able to relate these HSI concerns and map its impact to the Concept of Operations (CONOPS) as well as the System Threat Assessment Report (STAR).

It is the HSI Engineer's responsibility to coordinate with the Systems Engineer from a technical perspective to ensure strong consideration is also given to HSI standards especially when uniform configuration is necessary for ease of operation, safety, or training purposes. In developing an efficient, cost-effective system, the HSI Engineer must actively partake in the major technical reviews, as applicable. The following is a list of reviews, which is not all inclusive, that the HSI Engineer is highly recommended to attend and participate:

- Alternative System Review (concept exploration phase)
- System Requirements Review (program definition and risk reduction phase)
- System Functional Review (as appropriate to the acquisition)
- Preliminary Design Review (as appropriate to the acquisition)
- Critical Design Review (as appropriate to the acquisition)
- System Verification Review (as appropriate to the acquisition)

It is also imperative that the HSI Engineer not limit his participation to just the major reviews, but additionally participates in subsystem reviews including, where applicable, software specification, test readiness, and functional reviews (e.g., support, training, systems engineering, test, and manufacturing reviews).

The HSI Engineer ensures that each HSI SED contribution is timely, adequate, consistent, and compliant. The HSI Engineer ensures that HSI contributions are channeled through the Systems Engineering *Analyses and Control* activity. Systems Engineers manage the engineering process and activities depicted in Figure 3 while the HSI Engineer contributes to this process. The HSI Engineer supports concept and architecture development and analyses; modeling and simulation efforts; technology studies, as well as develops/derives their requirements and supports the requirements analyses and allocations process. The HSI Engineer participates in technical studies and solutions trades when HSI is a factor. They provide design analyses contributions to determine and adjust HSI allocations, update HSI predictions, and ensure confidence in attaining HSI requirements through analyses, demo, and test.

The HSI Engineer works closely with the System Engineers performing interface analyses, functional analyses, and the integration and verification and validation planning and execution. The SE conducts the management and control functions and integrates all engineering functions through the full system life cycle.

The HSI Engineer participates in the systems engineering process to help produce the proper balance between system performance and cost to ensure that requirements remain at affordable levels. His analysis of manpower, personnel, training, and supportability analyses is conducted as an integral part of the systems engineering process throughout the acquisition life cycle.

Relationship to other SEDs

The HSI Engineer ensures that solid technical contribution to the overall engineering advances and is appropriately applied through systematic control, collaboration and sharing across the organization. The HSI Engineer's contributions must be timed and applied in conjunction to other Specialty Engineers' performance of their unique contributions, while being provided to technical and program management for decision making. The following paragraphs demonstrate key interactions between the HSI Engineer and the various Specialty Engineers.

In every operational system, people play a significant role in the system's effectiveness and success. However, success is often attained when a system can readily expect consistent, predictable performance from equipment and personnel. Although, it is certainly easier to produce consistent results over time with equipment, people process information, communicate differently, and derive decisions in a variety of ways that is harder to predict. As a result, it is easy to recognize that human systems integration often overlaps with the reliability, availability, and maintainability (RAM) critical process in achieving the required level of RAM of personnel and equipment combination. The HSI Engineer teams with the RAM engineer to perform failure and error analyses aimed at determining and evaluating potential personnel and equipment related failure modes.

Personnel safety is also of paramount consideration during the design-development phases for any system. Hazardous items and conditions must be identified and either eliminated in the design of the system or mitigated through established instructions, in the work, test, maintenance or operational procedures. The HSI Engineer needs to collaborate with the System Safety Engineer to address the system safety requirements, while being sensitive to the human factors critical process, which includes manpower, personnel, training and environment, safety and occupational health (ESOH) hazards.

HSI is also referred to as the science of analysis and optimization of human characteristics and capabilities for integration with machine characteristics and capabilities in order to provide the most effective integrated human-machine system capable of accomplishing specified functions. From a logistics perspective, design considerations must be given to anthropometric factors (e.g. physical dimensions of the human being), human sensory factors (e.g., vision and hearing capabilities), physiological factors (e.g. human needs, expectations, motivation) and their interrelationships. As a result, the HSI Engineer must also forge a strong relationship with the Acquisition Logistics Engineer and Logistics Support Analyst and ensure incorporation of HSI data into Logistic Management Information (LMI). HSI evaluation as part of the Integrated Logistic Support (ILS) process provides the program office with the capability to ensure timely awareness of potential deficiencies requiring immediate and corrective action. It also provides an effective methodology for evaluating risk, life cycle cost, supportability, HSI, and support systems' performance from a total life cycle management perspective.

The HSI Engineer must also ensure a system is designed with features that reduce the risk of fratricide, detection, and the probability of being attacked. It must also enable the crew to withstand man-made hostile environments without aborting the mission or suffering acute chronic illness, disability or death. This can be achieved through close coordination with a Survivability Engineer.

In systems where software determines part of the human interface, the HSI Engineer must also collaborate closely with the Software Engineers and ensure the application of HSI principles to the software design. These same principles must also be applied to the development of maintenance and training manuals (electronic or hard copy) to ensure thoroughness, technical accuracy, suitable format of information presentation, appropriate reading level, appropriate level of technical sophistication, clarity, and suitable quality of illustrations.

The HSI Engineer is also required to establish solid coordination with T&E Engineers in establishing and conducting a T&E program to (1) demonstrate conformance of system, equipment, and facility design to HSI design criteria; (2) confirm compliance with system performance requirements where personnel performance is a system performance determinant; (3) secure quantitative measures of system performance that are a function of the human interaction with equipment; and (4) determine whether undesirable design or procedural features have been introduced. Deficiencies encountered in DT&E and IOT&E shall be resolved and fixes verified.

Tools Selection and Use

Typical HSI Functions Requiring Tools
Modeling & Simulations
HSI Requirements Analyses
Experiment Design, Growth, and Life Data Analysis
Manpower Training Research Information Systems (MATRIS)
Crew System Ergonomics Information Analysis Center (CSERIAC)

The HSI Engineer considers effectiveness and efficiencies gained by selecting and using the best choice of HSI tools considering the HSI tool requirements possibly for HSI interface verifications, requirements analyses, information sharing, and automated data exchanges with other tools, and other considerations.

Engineering Activities and Products over the Life Cycle

The following subsections delineate HSI contributions to engineering activities and technical products by DOD acquisition phase.

1. **Materiel Solution Analysis.** During this phase the HSI Engineer may provide inputs to and support the Capabilities Based Assessment process and the JCIDS process. The interactions with AFSPC's JCIDS process are described in the previous section. The HSI Engineer contributes to the MSA Phase technical activities and products. When warranted, the HSI Engineer may be required to perform or support a high level human integration analysis of proposed material solutions. The HSI Engineer provides and assesses human engineering factors to trades and alternative analyses to ensure balanced solutions. The HSI Engineer assists to identify and address human integration related risks.

MSA Phase – Technical Products Required	
SMC HSI Technical Products	**HSI Contributions to Other Organizations' Products**
High level human interface analysis	Operational Concepts
HSI inputs and factors for concept, architecture, technology studies, and trades	AoA Studies
System HSI Req'ts (draft)	Initial Capabilities Doc (ICD) Dev
Roadmap inputs – mitigations of HSI risks	DoDAF CVs, OVs

2. **Technology Development.** During this phase the HSI Engineer continues to provide inputs to and supports the JCIDS process. The HSI Engineer also supports all the engineering activities highlighted within the box titled *Engineering Activities for System & Segment Development & Design* Figure 19 to commence system definition and development. The HSI Engineer develops and contributes to development of the TD Phase technical products, as well as the development of CONOPs, Strategy and Doctrine and ensures that Capability Based Assessments (CBA) and Capability Requirements and Risk Assessments (CRRA) are properly supported to facilitate HSI inclusion in all subsequent steps of the life cycle. The HSI Engineer assists to define the system specification of requirements and human systems integration related requirements at the allocated level during this phase. The HSI Engineer works closely with reliability engineers, system safety and other SEDs to ensure HSI is appropriately factored into their analytical contributions.

TD Phase – Technical Products Required	
SMC HSI Technical Products	**HSI Contributions to Other Organizations' Products**
Inputs to System Concepts	Operational Concepts
Factors for Studies/ Trades	Operational Assessments
HSI Tech Req'ts, TRD, SRD, Specifications, ICDs, Standards Selection/ Tailor	Capabilities Development Doc (CDD)
HSI Analyses Rpts	DoDAF CVs, OVs

3. **Engineering & Manufacturing Development.** The HSI Engineer continues to provide inputs to and support the JCIDS process, and supports all the engineering activities highlighted within the box titled *Engineering Activities for Detailed Design* Figure 19 to commence detailed systems definition and development. The HSI Engineer develops and contributes to the development of the EMD Phase technical products. The HSI Engineer assists to define and assess the system detailed requirements. The HSI supports design analyses and trades to ensure balanced solutions that take into account HSI. The HSI Engineer works closely with reliability engineers, system safety and other SEDs to ensure HSI is appropriately factored into their analytical contributions. The HSI Engineer supports the planning and conduct of operational and sustainment demonstrations where the human interface is potential critical.

EMD Phase – Technical Products Required	
SMC HSI Technical Products	**HSI Contributions to Other Organizations' Products**
Update System Concept	Operational Concepts
Technical Studies/ Trades	Operational Assessments
System Tech Req'ts, TRD, SRD, Spec, ICDs	Capabilities Production Doc (CPD)
Inputs to system, production, fielding, sustain design docs	DoDAF CVs, OVs, SVs
HSI Analyses Rpts, models	
Test, Demo reports	

4. **Production & Deployment, Operations & Support.** The HSI Engineer continues to provide inputs to and supports the JCIDS process. The HSI Engineer develops and contributes to the development of the P&D / O&S Phase technical products. The HSI Manager and Engineer must work closely with operational, maintenance, systems engineering, logistics and training personnel prior to and during Developmental Test & Evaluation (DT&E), Initial Operational Test & Evaluation (IOT&E), Operational Test & Evaluation (OT&E) and Live Firing Test & Evaluation (LFT&E). In addition, the HSI Manager works to ensure all program planning documentation (e.g., TEMP, MER) continues to be updated, refined and tailored towards the system.

P&D / O&S Phase – Technical Products Required	
SMC HSI Technical Products	**HSI Contributions to Other Organizations' Products**
Inputs tech baseline engineering changes	Supportability Analyses Rpt
Analyses of production reports and test reports	Operational Assessments
Transition & Fielding Docs	
HSI Analyses Rpts	
V&V / T&E Reports	

HSI Engineers' Contributions to Program and Project Management

Each SMC program defines their business model and approach structure based primarily on their program objectives, program and technical challenges, organizational structure, as well as program and engineering planning (SEP plus detailed HSI planning).

Once parameters are established in the ICD and CDD, it is the HSI Manager's responsibility to ensure that they are addressed during the systems engineering process, included in the HSI plan, and the SEP.

The HSI Manager shall apply HSI to optimize total system performance, operational effectiveness, suitability, survivability, safety and affordability, and develop HSI planning. Each program is required to have a comprehensive plan for HSI that addresses the roadmap as well as documents analyses, results, and projections with regards to HSI concerns. This plan is to be included in the SEP or established as a stand-alone HSI plan as the program(s) may require. These HSI requirements must also be identified in and governed by other programmatic documentation such as Systems Training Plan and the Manpower Estimate (ME). The HSI Manager and HSI Engineer need to ensure HSI requirements are included in performance specifications and test criteria. The objective is to translate HSI thresholds and objectives in the capabilities documents into quantifiable and measurable system requirements.

The HSI Manager develops and implements the HSI program planning to achieve HSI objectives and requirements. The planning defines the HSI tasks and functions to be performed and products to be developed; timing of tasks, task outputs, resources (skills, tools, equipment), and completion criteria. The HSI Engineer plans tasks to integrate HSI activities within the program office, between Contractors and stakeholders. Program planning, budgeting and scheduling data enable the HSI manager to track the sequence of program events to determine if HSI inputs will have the optimum impact on design. HSI efforts must be well planned and must conform to the overall program office Integrated Master Schedule (IMS). The HSI Manager must also focus on identifying HSI-related tradeoffs and design risks associated with various design concepts or alternatives under construction. All major planning documents and schedules (Work Break Down Structure (WBS), Operational Requirements Document (ORD), TEMP, IMS) is required to be reviewed and cross referenced to ensure that all HSI matters have been identified and included.

HSI findings from design reviews, mockup inspections, demonstrations, and other early engineering tests must be utilized in planning and conducting later tests. HSI test planning needs to be directed toward verifying that the system can be operated, maintained, supported and controlled by user personnel in its intended operational environment, as well as highlight any HSI issues uncovered. It is critical that HSI issues be listed at a sufficiently high level in the WBS to better ensure receipt of funding allocations. Listing HSI issues at lower levels in the WBS may result in HSI concerns being overlooked, deemed less important in relation to other matters, or perceived as optional. Ultimately, this introduces the risk of not obtaining the required funding to successfully address HSI concerns and achieving total system optimization.

The HSI Manager and Engineer must provide input to and actively review the Integrated Master Plan (IMP), IMS and WBS to ensure that HSI efforts are appropriately identified and scheduled. This ensures that HSI functions occur at the proper time with respect to the other program functions. Meanwhile, the HSI manager is also responsible for monitoring the system baseline (configuration management), and justifying the HSI budget to the program office on the basis of anticipated improvements in performance, prevention of system problems, and cost savings. Additionally, it is essential that the HSI Manager be a proactive participant in IPTs and working groups to learn about HSI issues, secure funding for HSI analyses and gain the opportunity to influence design, and inform the Program Office what HSI can do for the program.

The HSI Manager is also responsible for coordinating with the requisite personnel conducting Cost and Operational Effectiveness Analysis (COEA), otherwise known as Analysis of Alternatives, to ensure that human-related issues are addressed in the financial considerations for all the alternative concepts.

The HSI Engineer provides full support to define the program and technical objectives where HSI challenges and risks are known or anticipated. The HSI Engineer assists to establish the business model, develop program planning and schedules, and define and implement program processes. The HSI Engineer ensures that the HSI components of the program are appropriately represented in the program plans, program schedules, WBS, and cost estimates. The HSI Engineer also reports their technical performance and progress. Additionally, the HSI Engineer shares in the risk management responsibilities to identify, assess, and propose mitigating actions of

HSI related risks, and supports the program manager's problem identification, resolution, and decision making processes.

The HSI Manager and Engineer must continue to remain abreast of new and emerging technologies relevant to the specific system being considered, as well as be knowledgeable of new HSI information sources and assessment methodologies that may be useful in performing analyses and making feasibility determinations. HSI Managers and Engineers contribute to the development of the program management products identified in the table.

SMC Program Management Products
PMD
SEP, IMP, IMS, WBS
Decision-making & problem solving inputs
Technical progression and issues reporting
LC Cost Estimate (CARDs)
Processes (OIs), HSI Plan
CRRA, Risk Management Inputs

Appendix O – Mass Properties Engineering

Mass Properties is an engineering discipline that is concerned with estimating weight, center of gravity, and inertia values of various vehicles, including space vehicles to include the upper stage vehicles, injection stages, satellites, satellite payloads, reentry vehicles, launch vehicles, ballistic vehicles, or other vehicles. Mass properties provide for the control, determination and documentation of the mass properties and mass properties limits of space vehicles and their subsystems and components. The mass properties of an item include the item's weight (or mass), center of gravity (or center of mass), mass moments of inertia, and mass products of inertia.

SMC Program Office Mass Properties (MP) Engineers have the responsibility to stand-up and execute the mass properties efforts for the development or modification of SMC space vehicles. The MP Engineer ensures effective prediction of the space vehicle mass properties parameters to support performance analyses, stability and control analyses, structural dynamics and loads analyses, and other analyses. The MP Engineer establishes and implements a mass properties control program with the objective of meeting the space vehicle mass properties requirements for weight, center of gravity, mass moments of inertia, and mass products of inertia as they apply. The control of weight growth is a continuous activity from system concept development through the last item of production. However a more restrictive definition usually refers to the technology development and EMD phases when most growth occurs. Costly fixes and possible schedule delays are avoided when weight prediction and control is applied while defining alternative enabling concepts or technologies and determining the preferred solutions. During detailed design, a major effort is required to keep the designers' attention focused on weight efficiency.

Applicable governance, standards, and guidance

Policy, directives, and instructions that mandate system integrity typically apply to space systems and require specialty disciplines such as reliability engineering, prognostics and health management, and rigorous design engineering including mass properties. For example, AFI 63-1201 requires that weapon system integrity programs be employed to ensure that system-level performance and safety requirements are met under any combination of design usage environments throughout the operational life of a system. Hence, mass properties design and test criteria must be established as it applies to space vehicles, launch vehicles, and missiles.
Table 20 below identifies the significant governance, standards, and guidance which generally require SMC compliance for MP Engineering.

Table 20 Governance, standards, and guidance that shape the Mass Properties Engineering discipline

Document No	Governance Title	Issue
AFI 63-1201	Life Cycle Systems Engineering	23 Jul 07
Document No	**Standards Title**	**Issue**
AIAA-S-120-2006	Mass Properties Control for Space Systems	01 Dec 06
SMC-T-002	Tailoring Instructions For AIAA-S-120-2006	08 Aug 08
Document No	**Guidance Title**	**Issue**
MIL-HDBK-1811	Mass Properties Control For Space Vehicles	12 Aug 98
SAWE RP 6	Standard Coordinate Systems for Reporting the Mass Properties of Flight Vehicles	03 Jun 00
SAWE RP 11	Mass Properties Control For Space Vehicles	03 Jun 00
CPAT	Critical Process Assessment Tool – Mass Properties	18 Sep 06

MP Engineers' Contributions to the Acquisition Life Cycle Framework

The DoD acquisition life cycle is defined by DoDI 5000.02. The MP Engineer contributions over this life cycle are best represented within the acquisition phase. Figure 20 provides the acquisition life cycle framework within which MP Engineers perform as well as the products that they must develop or contribute to the system development. This figure along with MIL-HDBK-1811 and SAWE recommended practices provide the guidance to perform MP planning, support pre and post contract award acquisition activities, and perform MP engineering and control across the system lifecycle. The SMC Program Office establishes and implements MP program strategies and objectives consistent with SMC acquisition and program objectives. The Program Office then develops, approves, and incorporates the more detailed MP planning, the Mass Properties Control Plan (MPCP), into the Test and Evaluation Master Plan (TEMP), Systems Engineering Plan (SEP) and higher level integrated planning (e.g., IMP, LCMP, LCSP) in accordance with current DoD policy and Program Office practices. Hence, MP planning is firmly based on program and technical objectives, strategies, DoD mandates and instructions, and MP related specifications and practices.

1. **Materiel Solution Analysis.** During this phase, the MP Engineer, with the developmental engineering team, begins to formulate predictive models and parameters of the space vehicle mass properties as system concepts are defined and provides inputs to and supports acquisition activities to include development of acquisition strategy, technology development strategy, and data strategies. The MP Engineer provides inputs to the cost estimates, RFP development for Contractor studies, and proposal evaluation activities. The MP Engineer also contributes to the development of the MSA Phase acquisition products.

MSA Phase – SMC Acquisition Products
Prepare MPCP
Inputs to ASP, TDS, DMS, TES
Draft MPCP; Inputs to SEP, LCMP
Inputs to LC Cost Estimate, CARD
Inputs to APB
RFP: MP tasks in PWS, MP data products in CDRLs; MP standard - Tailored

2. **Technology Development.** The MP Engineer provides inputs to and supports all program acquisition activities to include updates to the MPCP and inputs to the ASP, TDS and TEMP. MP strategies are likely integral to the MP controls to achieve system performance. The MP Engineer provides inputs to the cost model; development of the Cost Analysis Requirements Description (CARD); and solicitation/RFP development and proposal evaluation activities. The MP Engineer assists in the preparation of contract requirements for contractor and subcontractor MP controls, parameter determination, and developmental / qualification testing to meet MP and Program Office objectives and requirements. The MP Engineer also contributes to the development and updates to the TD Phase acquisition products. The MP Engineer assesses the effectiveness of the Contractor MP efforts.

TD Phase – SMC Acquisition Products
Update to MPCP; Inputs to SEP, LCMP, TEMP
Updates to ASP, TDS, DMS
LC Cost Estimate Update / CARD Development
Inputs to APB
RFP: MP tasks in PWS, MP data products in CDRLs; SMC- MP standards - tailored
SSP: evaluation criteria for MP

3. **Engineering & Manufacturing Development.** The MP Engineer provides inputs to and supports all program acquisition activities to include updates to the ASP, TDS, and DMS; updates to the TEMP; inputs to the cost model and CARD to reflect the cost elements; inputs to the APB. The MP Engineer supports the preparation of contract requirements such as mass properties performance work statements; identification and tailoring of the compliance test standards; preparation of the MP related CDRLs for submission of Contractor mass determinations and basis, expected mass growth, analyses, methods of analysis, etc. The MP Engineer also contributes to the development and updates to the EMD Phase acquisition products.

EMD Phase – SMC Acquisition Products
Update to TMPCP; Inputs to SEP, LCMP, TEMP
Updates to ASP, TDS, DMS
LC Cost Estimate Update / CARD Development
Inputs to APB
RFP: MP tasks in PWS, MP data products in CDRLs; SMC- MP standards - tailored
SSP: evaluation criteria for MP

4. **Production & Deployment, Operations & Support.** The MP Engineer provides inputs to and supports all program acquisition activities to include updates to the ASP, TDS and DMS; inputs to the cost model and CARD to reflect the MP cost elements required. The MP Engineer supports the preparation of contract requirements such as MP performance work statements; identification and tailoring of the MP standard; preparation of the MP related CDRLs for submission of Contractor mass determinations and basis, expected mass growth, analyses, methods of analysis, etc. The MP Engineer supports field performance and sustainment analyses to meet MP requirements and objectives. The MP Engineer ensures successful verification and validation of the MP parameters through developmental and operational test and evaluation.

P&D / O&S Phase – SMC Acquisition Products
Updates to ASP, TEMP
MPCP; Inputs to SEP, LCMP
RFP: MP tasks in PWS, MP data products in CDRLs; SMC- MP standards - tailored
CARD update

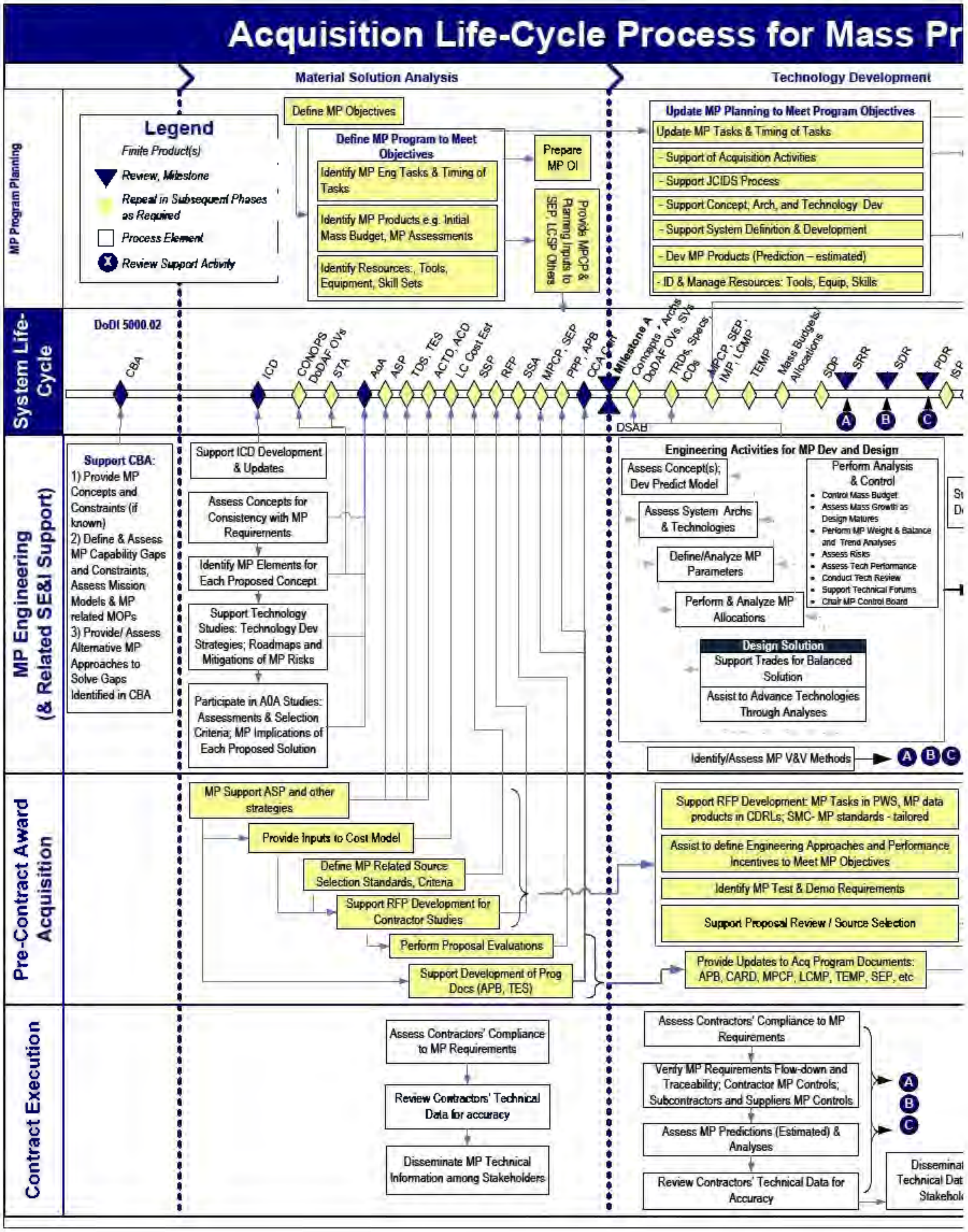
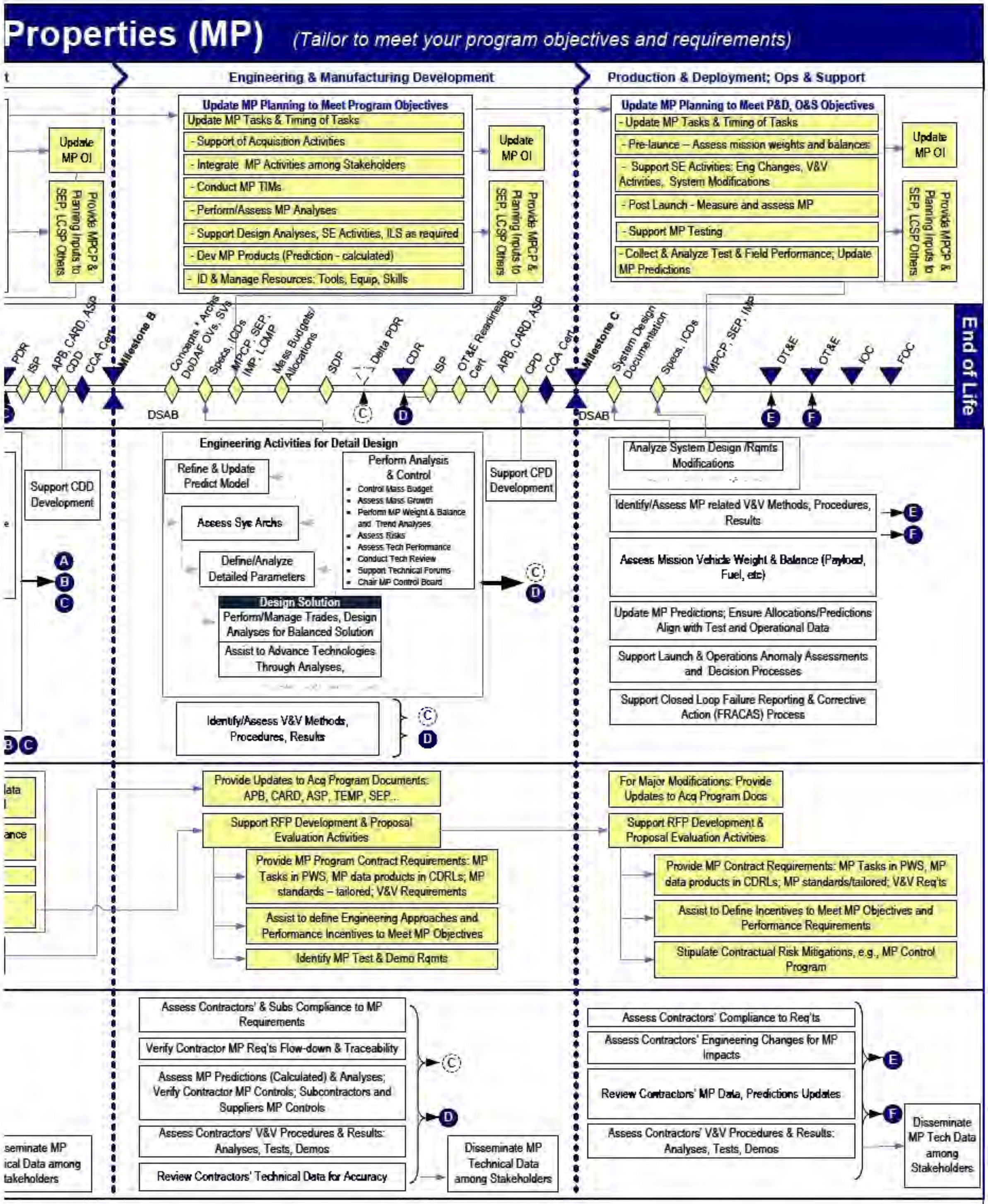


Figure 20 Acquisition life cycle process for SMC Mass Properties Engineering



Properties (MP) (Tailor to meet your program objectives and requirements)
Engineering & Manufacturing Development
Production & Deployment; Ops & Support
Update MP Planning to Meet Program Objectives
Update MP Tasks & Timing of Tasks
- Support of Acquisition Activities
- Integrate MP Activities among Stakeholders
- Conduct MP TIMs
- Perform/Assess MP Analyses
- Support Design Analyses, SE Activities, ILS as required
- Dev MP Products (Prediction - calculated)
- ID & Manage Resources: Tools, Equip, Skills
Update MP OI
Provide MPCP & Planning Inputs to SEP, LCSP Others
Update MP Planning to Meet P&D, O&S Objectives
- Update MP Tasks & Timing of Tasks
- Pre-launce – Assess mission weights and balances
- Support SE Activities: Eng Changes, V&V Activities, System Modifications
- Post Launch - Measure and assess MP
- Support MP Testing
- Collect & Analyze Test & Field Performance; Update MP Predictions
PDR
ISP
APB, CARD, ASP
CDD
CCA Cert
Milestone B
Concepts + Archs DoDAF OVs, SVs
Specs, ICDs
MPCP, SEP, IMP, LCMP
Mass Budgets/ Allocations
SDP
Delta PDR
CDR
ISP
OT&E Readiness Cert
APB, CARD, ASP
CPD
CCA Cert
Milestone C
System Design Documentation
Specs, ICDs
MPCP, SEP, IMP
OT&E
OT&E
IOC
FOC
End of Life
DSAB
DSAB
Support CDD Development
Engineering Activities for Detail Design
Refine & Update Predict Model
Access Sys Archs
Define/Analyze Detailed Parameters
Perform Analysis & Control
Control Mass Budget
Assess Mass Growth
Perform MP Weight & Balance and Trend Analyses
Assess Risks
Assess Tech Performance
Conduct Tech Review
Support Technical Forums
Chair MP Control Board
Design Solution
Perform/Manage Trades, Design Analyses for Balanced Solution
Assist to Advance Technologies Through Analyses,
Support CPD Development
Identify/Assess V&V Methods, Procedures, Results
Analyze System Design /Rqmts Modifications
Identify/Assess MP related V&V Methods, Procedures, Results
Assess Mission Vehicle Weight & Balance (Payload, Fuel, etc)
Update MP Predictions; Ensure Allocations/Predictions Align with Test and Operational Data
Support Launch & Operations Anomaly Assessments and Decision Processes
Support Closed Loop Failure Reporting & Corrective Action (FRACAS) Process
Provide Updates to Acq Program Documents: APB, CARD, ASP, TEMP, SEP...
Support RFP Development & Proposal Evaluation Activities
Provide MP Program Contract Requirements: MP Tasks in PWS, MP data products in CDRLs; MP standards – tailored; V&V Requirements
Assist to define Engineering Approaches and Performance Incentives to Meet MP Objectives
Identify MP Test & Demo Rqmts
For Major Modifications: Provide Updates to Acq Program Docs
Support RFP Development & Proposal Evaluation Activities
Provide MP Contract Requirements: MP Tasks in PWS, MP data products in CDRLs; MP standards/tailored; V&V Req'ts
Assist to Define Incentives to Meet MP Objectives and Performance Requirements
Stipulate Contractual Risk Mitigations, e.g., MP Control Program
Assess Contractors' & Subs Compliance to MP Requirements
Verify Contractor MP Req'ts Flow-down & Traceability
Assess MP Predictions (Calculated) & Analyses; Verify Contractor MP Controls; Subcontractors and Suppliers MP Controls
Assess Contractors' V&V Procedures & Results: Analyses, Tests, Demos
Review Contractors' Technical Data for Accuracy
Disseminate MP Technical Data among Stakeholders
Assess Contractors' Compliance to Req'ts
Assess Contractors' Engineering Changes for MP Impacts
Review Contractors' MP Data, Predictions Updates
Assess Contractors' V&V Procedures & Results: Analyses, Tests, Demos
Disseminate MP Tech Data among Stakeholders

MP Engineers' Contributions to the Engineering Life Cycle Framework

Relationship to the SE Organization

The MP Engineer plans and implements the space vehicle mass properties determination and control program within the context and full support of the overarching Systems Engineering function. The MP Engineer ensures that each mass properties contribution is timely, adequate, consistent, and compliant. The MP Engineer ensures that their SED contributions to concept and architecture development, requirements analyses, design trades and analyses, and test are channeled through the Systems Engineering *Analyses and Control* activity. Systems Engineers manage the engineering process and activities depicted in Figure 3 while the MP Engineer contributes to this process through mass properties determination, control, and documentation of space vehicles and their subsystems and components. The MP Engineer ensures effective prediction of the space vehicle mass property parameters through estimated/calculated/measured mass properties, mass growth allowance, analyses, and risk assessments to support performance analyses, stability and control analyses, and structural dynamics and loads analyses. The MP Engineer also works with the System Engineers ensuring mass properties factors are integral to space vehicle design and performance trades.

Relationship to other SEDs

The MP Engineer ensures results of mass properties are applied to the overall engineering effort through systematic control, collaboration and sharing across the organization to facilitate system development and implementation. For example, the testing results are evaluated to assess progress of the design to assure that such items as weight and balance bogies are being met. Early emphasis of mass properties and its budget planning contributes to reduction of risk throughout the acquisition lifecycle. The MP Engineer also ensures the spacecraft weight is within launch vehicle capabilities and that the weight growth is within the allocated margin.

MP Engineers, by the nature of their function, must interface with all specialty disciplines involved with the design, development, manufacturing, deployment and operation of a system that may impact the mass properties of the space vehicle. MP Engineer interactions include:

- Architecture Engineers and Concept Developers to provide mass properties data to support alternative analyses and ensure predictive mass properties model is current.
- Design Engineers to ensure design solutions are current for mass properties determinations; provide data to designers for optimal component selection and location for Space Vehicle (SV) balance; provide segmented mass properties for structural and thermal analysis.
- T&E Engineer to coordinate the equipment and procedures for mass properties measurements:
    - determination of accuracies required
    - determination and design of test fixtures to meet requirements
    - calibration of equipment
    - M&S - dynamics Finite Element Modeling (FEM) where mass properties data are utilized in FEM to determine vehicle dynamic response.
- Survivability for optimum component selection as well as component and space vehicle shielding/hardening methods.
- PMP to influence PMP selections, packaging to reduce weight.
- Reliability Engineering to collaborate and attain balanced solutions for redundancy decisions
- Other specialists as required.

Tools Selection and Use

The MP Engineer considers effectiveness and efficiencies gained by selecting and using the best choice tools considering the mass properties functions of MP prediction modeling, MP determination of parameters, MP database management and control, information sharing, automated data exchanges with other tools, etc.

Typical Mass Properties Functions Requiring Tools
MP Predictive modeling
Mass Properties Requirements Analyses & Allocations
MP database management and control
Development/Operational testing

Engineering Activities and Products over the Life Cycle

The Mass Properties Engineer is responsible for developing and implementing a mass properties determination and control program to provide analyses and support technical decisions to determine the preferred system concept, viable technologies, performance requirements, design solutions. Establishing and controlling mass budgets and providing rigorous mass properties analyses in support of the overall engineering is essential to meet the program performance and cost goals as well as early identification of potential program risks.

The following subsections delineate mass properties contributions to engineering activities and technical products by DOD acquisition phase. Refer to AIAA-S-120-2006, MIL-HDBK-1811, and SAWE recommended practices for a more complete list of MP Engineering activities and products that are prepared by the Program Office and their Contractors.

1. **Materiel Solution Analysis.** During this phase the MP Engineer supports the JCIDS process. The MP Engineer, with the development engineering team, formulates predictions (estimated) and parameters of the space vehicle mass properties as system concepts are defined and provides inputs to and supports acquisition activities to include development of acquisition strategy, technology development strategy, and data strategies. The MP Engineer initiates the Mass Properties Control Program, establishes and allocates the initial mass properties budget, and determines the test strategy to maximize efficiencies. The MP Engineer also contributes to the development of the MSA Phase products.

MSA Phase – Technical Products Required	
SMC Mass Properties Technical Products	**MP Contributions to Other Organizations' Products**
Initial MP control plan and Process	Space vehicle preferred enabling concept and AoA
Mass properties prediction – estimated + Wt growth allowance	ICD
Initial mass budget; target launch vehicle type; subsystem and component mass allocation	DoDAF CVs, OVs
Vehicle performance analyses	
MP Requirements (draft)	
Mitigations of MP risks	

2. **Technology Development.** During this phase the MP Engineer continues to support the JCIDS process. The MP Engineer also supports the systems engineering activities highlighted within the box titled *Engineering Activities for Development & Design* Figure 20 to commence system definition and development. The Mass Properties Engineer refines the mass properties predictions, performs trend analyses, and evaluates technology and design solutions to satisfy systems performance requirements. The Mass Properties Engineer continues to derive and apply mass properties parameters and allocations through the requirements analysis process and assesses verification tests of prototypes or preproduction articles. The Mass Properties Engineer supports the T&E and M&S planning. The Mass Properties Engineer supports the concept, architectural, technology development, and engineering trades and analyses to ensure the concept, architectural, technology and design solutions are determined considering mass properties influences. The MP Engineer develops and contributes to development of the TD Phase technical products.

TD Phase – Technical Products Required	
SMC Mass Properties Technical Products	**MP Contributions to Other Organizations' Products**
MP Control Plan and Process	Inputs to operational concepts
Mass properties prediction – estimated + Wt growth allowance	Inputs to DoDAF CVs, OVs
MP mass budget; trend analysis	Inputs to tech assessments
MP factors for concept, arch, technology studies, and trades	Inputs to AoA Studies
MP Tech Req'ts, TRD, specs, std selection/ Tailor ; V&V req'ts	Inputs to CDD
Architectural inputs: System & Service DODAF Views; ISP	
Space vehicle preliminary design and performance analyses	
RFP inputs: SOO, PWS Tasks, CDRLs, DIDs; MP standards	

3. **Engineering & Manufacturing Development.** During this phase the MP Engineer continues to support the JCIDS process. The MP Engineer supports the systems engineering activities highlighted within the box titled *Engineering Activities for Development & Design* Figure 20 to commence detailed systems definition and development. The MP Engineer updates and implements the MPCP and continues to implement the mass properties control program to meet the space vehicle mass properties requirements for weight, center of gravity, mass moments of inertia, and mass products of inertia as they apply. The MP Engineer updates the mass properties predictions (calculated), refines the space vehicle mass properties parameters focusing on weight efficiencies and system performance. The MP Engineer assesses test methodologies and limitations. Mass properties engineering efforts are also concentrated on analyzing and controlling the system design to assure that 1) the design is evolving consistent with the MP weight and balance requirements and allocations, 2) design qualification is progressing consistent with the MP requirements. The MP Engineer monitors contractor's documentation such as mass growth allowance and depletion schedules, detailed mass properties, analyses, and verification plans and results.

EMD Phase – Technical Products Required	
SMC Mass Properties Technical Products	**MP Contributions to Other Organizations' Products**
MP Control Plan and Process	Inputs to operational concepts
Mass properties prediction – calculated + Wt growth allowance	Inputs to DoDAF CVs, OVs
MP mass budget; allocations; trend analysis	Inputs to CPD
MP inputs and factors for design analyses and trades	
MP Tech Req'ts, specifications, standards -tailored ; V&V req'ts	
Architectural inputs: System and Service DODAF Views; TVs, ISP	
Space vehicle design and performance analyses	
RFP inputs: SOO, PWS Tasks, CDRLs, DIDs; MP standards	

4. **Production & Deployment, Operations & Support.** During this phase, MP efforts are concentrated on the evaluation of proposed engineering changes, assessments of production and fielding tests, and production and fielding challenges that potentially alter the baselined design weight and balance. The MP Engineer continues to assess the design to determine if it meets the contractual requirements and ensures that build and integration activities do not induce additional MP risks. The MP Engineer provides inputs to and supports the solicitation/RFP development and proposal evaluation activities. The MP Engineer identifies other contract requirements: production and operational test & demo requirements: operational performance and sustainment analyses to meet MP program objectives and requirements. The MP Engineer assists the T&E Engineer in the preparation of the Certificate of System Readiness to enter OT&E. The MP Engineer develops and contributes to the development of the P&D / O&S Phase technical products.

P&D / O&S Phase – Technical Products Required	
SMC Mass Properties Technical Products	**MP Contributions to Other Organizations' Products**
Inputs tech baseline engineering changes impacting PM	Operational Assessments
Mass properties – measured	Survivability Assessment
Analyses of production test and OT&E failure reports	Support to Launch Operation
Analysis of weight and balance payload / fuel calculations	
Analyses of OT&E results; performance and field test reports	

MP Engineers' Contributions to Program and Project Management

Each SMC program defines their business model and approach based primarily on program objectives, technical challenges, organizational structure, and required engineering planning including mass properties engineering for cost-effective execution.

The MP Engineer develops and implements a mass properties determination and control approach to achieve Program Office management objectives and requirements. The approach, which is documented in the MPCP, defines the MP engineering tasks and functions to be performed and products to be developed: timing of tasks, task outputs, resources (skills, tools, equipment, and completion criteria). The MP Engineer plans tasks and integrates the mass properties activities within the Program Office, between Contractors and stakeholders. The MP Engineer plans the tasks to support the engineering and decision processes: technical review forums: support SE&I activities, risk management, integration, and system modifications. Execution of the MP Engineer planning is typically defined through an Operating Instruction. The MP provides full support to define the program and technical objectives where MP challenges and risks are known or anticipated. The essential MP information is provided to program management to determine if the program is ready for full scale production or if the design and production processes need to be refined.

The MP Engineer assists to establish the business model, develop program planning and schedules, and define and implement program processes. The MP Engineer ensures the mass properties elements of the program are appropriately represented in the program plans, program schedules, work breakdown schedules, cost estimates. The MP Engineer also reports their technical performance and progress. The MP Engineer shares in the risk management responsibilities to identify, assess, and propose mitigating actions of MP related risks. They also support the Program Manager's problem identification, resolution, and decision-

SMC Program Management Products
MPCP, SEP, IMP, IMS, WBS
Decision-making & problem solving inputs
Technical progression and issues reporting
LC Cost Estimate (CARDs)
Processes (OIs)
Risk Management Inputs

making processes. Mass Properties tasks that support Program Management includes evaluating and monitoring contractor, subcontractors mass properties control efforts.

Appendix P – Electromagnetic interference/ Electromagnetic compatibility Engineering

A system in development must be compatible to all defined environments to which they are intended to be exposed. The system must operate in various operating modes and mission phases, while working harmoniously in concert with other systems. Each system must be electromagnetically compatible among all subsystems and equipment within the system, including the personnel that interact with the system, and with environments caused by emitters and other electromagnetic sources external to the system to ensure safe and proper operation and performance.

In the simplest terms, Electromagnetic interference (EMI) is the detrimental effect stray radiated electromagnetic energy has on the performance of a system. Electromagnetic compatibility (EMC) involves the control and reduction of this energy. Our space and ground systems must be able to operate and remain free of overstress and anomalies caused by either intentional or extraneous electromagnetic (EM) energy emanating within or outside the system from man-made or natural sources. In essence, EMC refers to the capability of electrical and electronic systems, equipment, and devices to operate in their intended electromagnetic environment within a defined margin of safety, and at design levels of performance, without suffering or causing unacceptable degradation as a result of Electromagnetic Interference (EMI). While EMI is concerned with electromagnetic disturbances that interrupt, obstruct, degrade or limit the effective performance of electronic or electrical systems, transmission channels, equipment or devices.

However the Program Office EMI/EMC Engineer (herein referred to the EMC Engineer), Survivability Engineer, Human Systems Integration, Spectrum Manager, and other contributors must consider a broader context of electromagnetic environmental effects (E3). E3 encompasses the electromagnetic effects addressed by the disciplines of electromagnetic compatibility (EMC), electromagnetic interference (EMI), electromagnetic vulnerability (EMV), electromagnetic pulse (EMP), electronic protection (EP), electrostatic discharge (ESD), and hazards of electromagnetic radiation to personnel (HERP), ordnance (HERO), and volatile materials (HERF), lightning, precipitation static, and electrostatic discharge. E3 includes the electromagnetic effects generated by all EME contributors including radio frequency (RF). Consideration of these various aspects of E3 could be crucial to fielding a system that is electromagnetically compatible with itself, surrounding systems, and the operational electromagnetic environment. While EMI, including interference caused by spectrum management problems, can cause catastrophic failures, the majority of interference problems render systems only partially effective reducing operational readiness and increasing costs.

SMC's Programs establish and designate responsibility for managing and executing the EMI/EMC management program. Its responsibilities include planning, supervising and ensuring essential EMI/EMC and management efforts are integrated with various acquisitions, management, & engineering processes. The program office ensures effectiveness and compliancy to the assorted policies, DoD mandates, instructions, and SMC acquisition program and technical objectives, as it pertains to the implementation of EMI/EMC program strategies and plans.

Applicable governance, standards, and guidance

EMI/EMC is an integral part of several mandates including public policies, directives, and instructions. It is a specialty engineering discipline that interacts with multiple functional disciplines within the Systems Engineering realm including the Systems Engineer, Survivability Engineer, Human Systems Integration, Spectrun Manager, Software Engineer, Test and Evaluation, and others. Table 21 below identifies the significant governance which generally requires SMC compliance for EMI/EMC, EMI/EMC standards applicable to SMC procurements, and guidance.

Table 21 Governance, standards, and guidance that shape the EMI/EMC Discipline

Document No	Governance Title	Issue
NTIA	Manual of Regulations for Radio Frequency Management	May 10
DoDD 3222.3	DoD Electromagnetic Environmental Effects (E3) Program	08 Sep 04
DoDD 4630.05	Interoperability & Supportability of IT & National Security Systems	05 May 04
DoDI 4650.01	Policy For The Management & Use of the Electromagnetic Spectrum	09 Jan 09
DoDD 5000.01	The Defense Acquisition System	12 May 03
DoDI 4630.8	Procedures for Interoperability and Supportability of IT and NSS	30 Jun 04
DoDI 5000.02	Operation of the Defense Acquisition System	08 Dec 08
DoDI 6055.11	Protection of DoD Personnel from Exposure to RF Radiation and Military Exempt Lasers	19 Aug 09
CJCSI 6212.01E	Operation of the Joint Capabilities Integration and Development System	01 May 07
AFI 10-601	Interoperability and Supportability of IT and National Security Systems	15 Dec 08
AFI 10-602	Operational Capability Requirements Development	12 Jul 10
AFI 63-1201	Determining Mission Capability & Supportability Requirements	18 Mar 05
AIAA-S-121-200Z	Life Cycle Systems Engineering	23 Jul 07
DOT&E E3 PM	Policy on OT&E of E3 & Spectrum Management	25 Oct 99
FIPS PUB 140-2	Security Requirements for Cryptographic Modules (mandated by DISR)	11 Jan 94
Document No	**Standard Title**	**Issue**
MIL-STD-1542B	EMC and Grounding Requirements for Space System Facilities, USAF	15 Nov 91
MIL-STD-1541A	Electromagnetic Compatibility Requirements for Space Systems, USAF	30 Dec 87
MIL-STD-464A	Electromagnetic EMI/EMC Effects Requirements for Systems	19 Dec 02
MIL-STD-461F	Electromagnetic Emissions and Susceptibility, Requirements for the Control of Electromagnetic Interference	10 Dec 07
SMC-S-001	Systems Engineering Requirements and Products	12 July 10
SMC-S-008	Electromagnetic Compatibility Requirements For Space Equipment And Systems	13 June 08
SMC-S-016	Test Requirements for Launch, Upper-Stage and Space Vehicles	13 Jun 08
SMC-S-021	Technical Reviews & Audits for Systems, Equipment and Computer Software	15 Sep 09
IEEE C63.14	ANS Dictionary for Technologies of EMC, EMP, & ESD	21 Apr 92
Document No	**Guidance Title**	**Issue**
CJCSM 3170.01C	Operation of the Joint Capabilities Integration and Development System	01 May 07
DAG	The Defense Acquisition Guidebook	05 May 10
MIL-HDBK-235	Electromagnetic Environment Considerations For Design & Procurement Of Electrical & Electronic Equipment, Subsystems And Systems	22 Dec 00
MIL-HDBK-237	Electromagnetic EMI/EMC Effects and Spectrum Certification Guidance for the Acquisition Process, Department of Defense	20 May 05
AFI 63-101	Acquisition and Sustainment Life Cycle Management	22 Mar 11

The list of data Item Descriptions (DIDs) provided below correlate with Mil STD 461 data deliverables for EMI/EMC.

Date Item Title	Date Item Description (DID)
Electromagnetic Interference Control Procedures (EMICP)	DI-EMCS-80199C
Electromagnetic Interference Test Report (EMITR)	DI-EMCS-80200C
Electromagnetic Interference Test Procedures (EMITP)	DI-EMCS-80201C
Electromagnetic Compatibility Program Procedures	DI-EMCS-81528

EMI/EMC Engineers' Contributions to the Acquisition Life Cycle Framework

In general, EMI/EMC consists of the following four main categories that an EMC Engineer (EMCE) needs to recognize: (1) conducted emissions; (2) conducted susceptibility; (3) radiated emissions; and (4) radiated susceptibility. Below are brief descriptions of each of the categories.

Conducted emissions. Refers to the electromagnetic energy created in an electronic device that is coupled to the device's power lines, antenna inputs, or interconnecting cables in the system.

Conducted susceptibility. Is concerned with the ability of an electronic circuit, equipment, subsystem, or system to operate acceptably when subjected to RF voltage or current on interconnecting conductors.

Radiated emissions. Refers to the unintentional release of electromagnetic energy from an electronic device that propagates away from the device.

Radiated susceptibility. Is concerned with the ability of an electronic circuit, equipment, subsystem or system to operate acceptably when subjected to an externally generated electromagnetic field.

The DoD acquisition life cycle is defined by DoDI 5000.02. EMI/EMC engineering contributions over this life cycle are best represented within the phase of acquisition. Figure 21 provides the acquisition life cycle framework within which the EMCE performs as well as the products that the EMCE develops or contributes to their development.

The SMC Program Office establishes and implements EMI/EMC engineering program strategies and objectives consistent with the tenets of appropriate policies, SMC acquisition objectives, and program objectives. The Program Office develops, attains approval for, and implements EMI/EMC engineering planning into higher level integrated planning (e.g., SEP, IMP, LCMP, LCSP) in accordance with current DoD policy. This planning is firmly based on program and technical objectives, strategies, DoD mandates, and instructions.

An effective EMI/EMC program supports all of the major acquisition activities through the full system life cycle. The planning sufficiently defines the EMI/EMC program to achieve the EMI/EMC engineering and overall program objectives and requirements; specifies tasks and functions to be performed, timing of tasks, resources required, and products to be developed; forms the basis for the development of the program EMI/EMC engineering or Operating Instruction (OI) – if required as a critical process. The EMI/EMC engineering planning and OI are then reflected appropriately in the WBS, IMS, and other program documents that address EMI/EMC engineering related elements. The EMI/EMC engineering planning is executed concurrently with the Program Office OI that documents the process to perform, control, and integrate all EMI/EMC engineering and management activities for each phase of acquisition. The SMC Program Office EMI/EMC engineering plan and OI are also based upon the appropriate program-approved life cycle. The following subsections delineate the EMCE contributions to acquisition activities and products by DoD acquisition Phase.

1. **Materiel Solution Analysis.** During this phase, the EMCE provides inputs to and supports select program acquisition activities to include the development of the acquisition strategy if applicable, inputs to the cost estimates, solicitation/RFP development for Contractor studies, and proposal evaluation activities. The EMCE may provide inputs to the initial regulatory spectrum supportability risk assessment (SSRA) to identify and refine issues related to the EM environment. The EMCE contributes to the development of the MSA Phase acquisition products.

MSA Phase – SMC Acquisition Products
Inputs to ASP, TDS, DMS, TES
Inputs to LC Cost Estimate
Inputs to DD Form 1494 (Stage 1 SS Certification)
RFP inputs (EMI/EMC requirements; EMI/EMC assessment requirements; High level EMI/EMC assessments of concepts
Inputs to APB, CCA
Inputs to LCMP, SSRA

2. **Technology Development.** Throughout the TD phase, the EMCE continues to provide inputs and supports all program acquisition activities. The EMCE is actively involved in contributing toward the development of the acquisition strategy if EMI/EMC is a risk component. The EMCE provides updates to the cost model and development of the Cost Analysis Requirements Description (CARD), solicitation/RFP development and proposal evaluation activities. EMCE also identifies other EMI/EMC related contract requirements, including related tasks, as well as test & demo requirements to meet EMI/EMC engineering objectives. During this phase, the EMCE provides inputs to the initial technical and initial operational SSRAs to identify EM interactions that require further study. The EMCE is an important contributor to the development and refinement of the TD Phase acquisition products.

TD Phase – SMC Acquisition Products
Updates to ASP, TDS, DMS
Inputs to LC Cost Estimate Update / CARD Development
Inputs to DD Form 1494 (Stage 2 SS Certification)
RFP: EMI/EMC objectives in the SOO; EMI/EMC related tasks in PWS, EMI/EMC CDRLs; SMC-EMI/EMC standards - tailored
APB: EMI/EMC objectives & related concept descriptions
Detailed EMI/EMC planning, LCMP, TEMP, ISP
SSRA

3. **Engineering & Manufacturing Development.** As the acquisition process becomes more refined and the program enters the EMD phase, the EMCE's early contributions to the program become more evident and often influence the ultimate success of the program. EMCE contributions and on-going support for all program acquisition activities in the EMD phase may remain a critical component of the process. During this phase, the EMCE provides input to a detailed regulatory and a detailed technical SSRA to ensure all EM issues have been identified and are being mitigated. Like the previous phase, the EMCE is responsible for updating the acquisition strategy, the cost model to reflect the actual technical solutions determined, as well as the CARD. Additionally, the EMCE also supports the solicitation/RFP development and proposal

EMD Phase – SMC Acquisition Products
Updates to ASP, TDS, DMS
CARD update
Inputs to DD Form 1494 (Stage 3 SS Certification)
RFP: EMI/EMC objectives in the SOO; EMI/EMC related tasks in PWS, EMI/EMC CDRLs; SMC-EMI/EMC standards - tailored
APB: EMI/EMC objectives & related concept descriptions
Detailed EMI/EMC planning, LCMP, TEMP updates
SSRA

evaluation activities including providing technical inputs such as technical requirements, compliance standards, engineering activities including providing technical inputs such as technical requirements, compliance standards, engineering approaches, incentives, and warranty programs to meet program objectives. The EMCE identifies other contract requirements as necessary to meet EMI/EMC engineering objectives, and contributes to the development and update of EMD Phase acquisition products.

4. **Production & Deployment, Operations & Support.** The EMCE provides inputs to and supports all program acquisition activities to include updates to the acquisition strategy, the cost model to reflect the actual technical solutions determined, the CARD, and any final regulatory, technical and operational input to the SSRA prior to requesting authorization to operate for other than testing. The EMCE also supports the solicitation/RFP development, proposal evaluation activities, as well as identifies other contract requirements; production and field test & demo requirements; field performance and sustainment analyses to meet EMI/EMC engineering objectives.

P&D / O&S Phase – SMC Acquisition Products
Updates to ASP, TDS, DMS
Inputs to DD Form 1494 (Stage 4 SS Certification)
RFP: EMI/EMC objectives in the SOO; EMI/EMC related tasks in PWS, EMI/EMC CDRLs; SMC-EMI/EMC standards - tailored
Detailed EMI/EMC planning, LCMP, TEMP updates
CARD update
SSRA

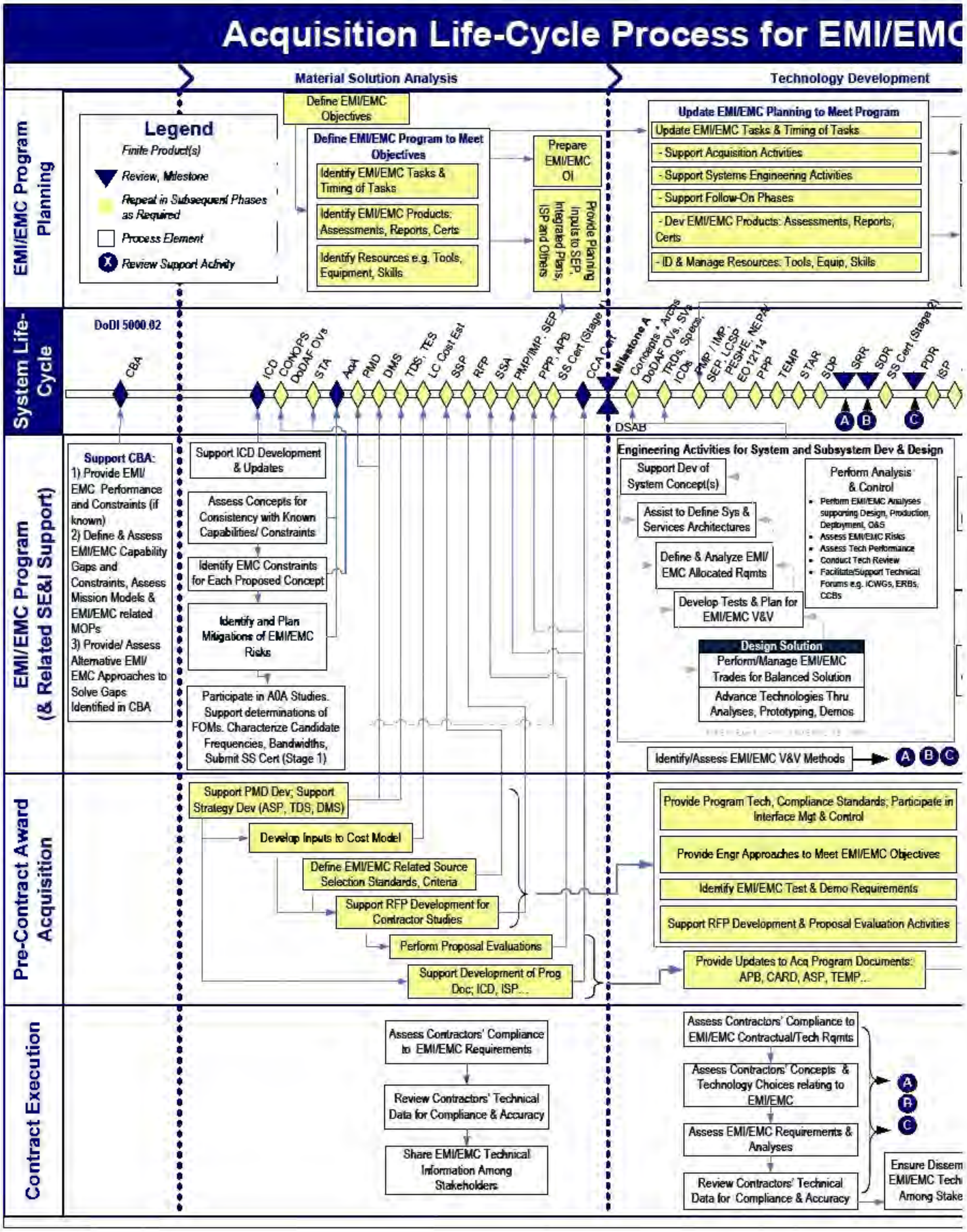
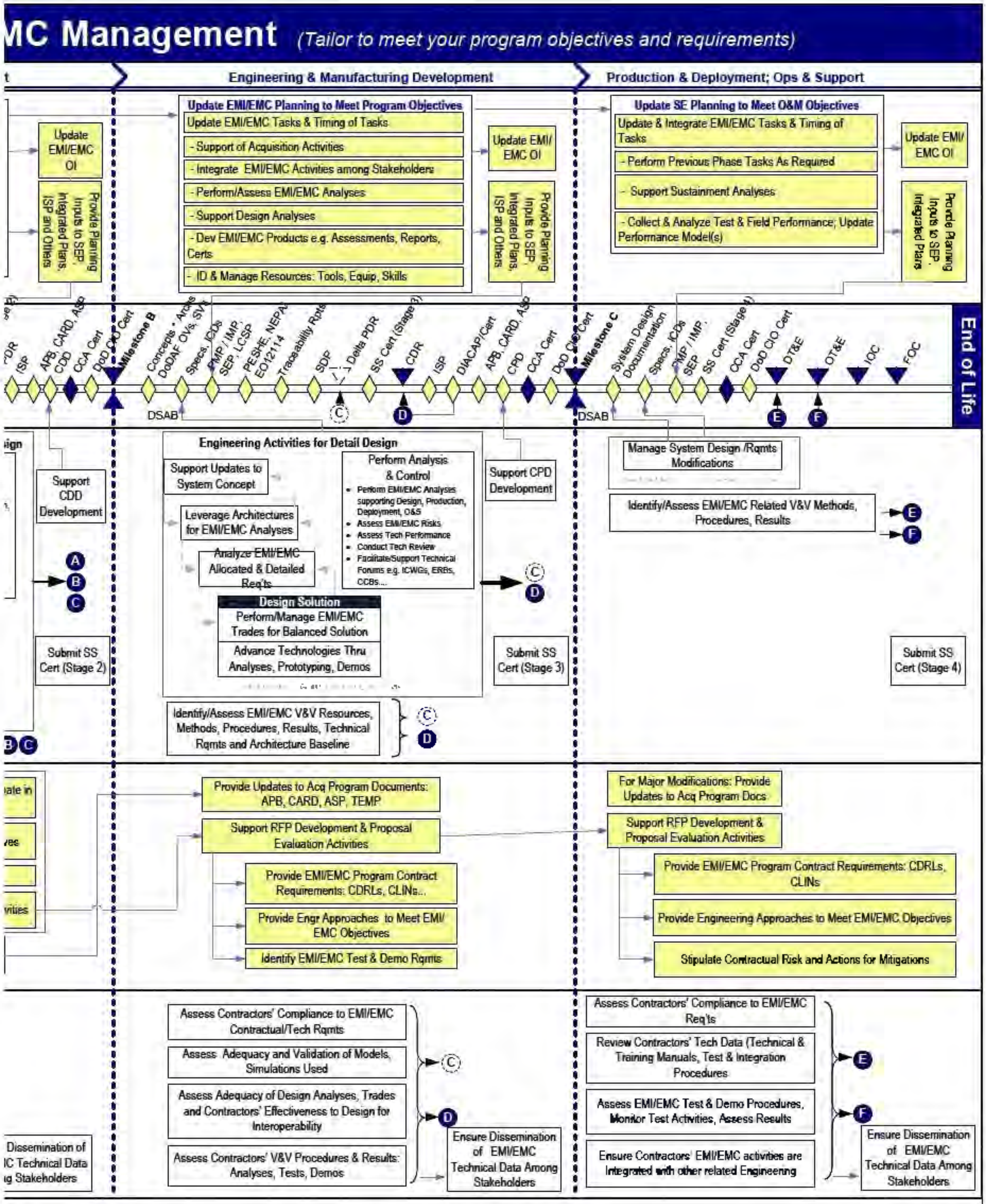


Figure 21 Acquisition life cycle process for SMC EMC/EMI Engineering


MC Management
(Tailor to meet your program objectives and requirements)
Engineering & Manufacturing Development
Production & Deployment; Ops & Support
Update EMI/EMC OI
Provide Planning Inputs to SEP, Integrated Plans, ISP and Others
Update EMI/EMC Planning to Meet Program Objectives
Update EMI/EMC Tasks & Timing of Tasks
- Support of Acquisition Activities
- Integrate EMI/EMC Activities among Stakeholders
- Perform/Assess EMI/EMC Analyses
- Support Design Analyses
- Dev EMI/EMC Products e.g. Assessments, Reports, Certs
- ID & Manage Resources: Tools, Equip, Skills
Update EMI/EMC OI
Provide Planning Inputs to SEP, Integrated Plans, ISP and Others
Update SE Planning to Meet O&M Objectives
Update & Integrate EMI/EMC Tasks & Timing of Tasks
- Perform Previous Phase Tasks As Required
- Support Sustainment Analyses
- Collect & Analyze Test & Field Performance; Update Performance Model(s)
Update EMI/EMC OI
Provide Planning Inputs to SEP, Integrated Plans
PDR
ISP
APB, CARD, ASP
CDD
CCA Cert
DoD CIO Cert
Milestone B
Concepts • Arcs
DODAF OVs, SVs
Specs, ICDs
PMP / IMP, SEP, LCSP
PESHE, NEPA, EO12114
Traceability Rpts
SDP
Delta PDR
SS Cert (Stage 3)
CDR
ISP
DIACAP/Cert
APB, CARD, ASP
CPD
CCA Cert
DoD CIO Cert
Milestone C
System Design Documentation
Specs, ICDs
PMP / IMP, SEP
SS Cert (Stage 4)
CCA Cert
DoD CIO Cert
DT&E
OT&E
IOC
FOC
End of Life
DSAB
DSAB
Support CDD Development
Submit SS Cert (Stage 2)
Engineering Activities for Detail Design
Support Updates to System Concept
Leverage Architectures for EMI/EMC Analyses
Analyze EMI/EMC Allocated & Detailed Req'ts
Perform Analysis & Control
Perform EMI/EMC Analyses supporting Design, Production, Deployment, O&S
Assess EMI/EMC Risks
Assess Tech Performance
Conduct Tech Review
Facilitate/Support Technical Forums e.g. ICWGs, ERBs, CCBs...
Design Solution
Perform/Manage EMI/EMC Trades for Balanced Solution
Advance Technologies Thru Analyses, Prototyping, Demos
Support CPD Development
Submit SS Cert (Stage 3)
Identify/Assess EMI/EMC V&V Resources, Methods, Procedures, Results, Technical Rqmts and Architecture Baseline
Manage System Design /Rqmts Modifications
Identify/Assess EMI/EMC Related V&V Methods, Procedures, Results
Submit SS Cert (Stage 4)
Provide Updates to Acq Program Documents: APB, CARD, ASP, TEMP
Support RFP Development & Proposal Evaluation Activities
Provide EMI/EMC Program Contract Requirements: CDRLs, CLINs...
Provide Engr Approaches to Meet EMI/EMC Objectives
Identify EMI/EMC Test & Demo Rqmts
For Major Modifications: Provide Updates to Acq Program Docs
Support RFP Development & Proposal Evaluation Activities
Provide EMI/EMC Program Contract Requirements: CDRLs, CLINs
Provide Engineering Approaches to Meet EMI/EMC Objectives
Stipulate Contractual Risk and Actions for Mitigations
Assess Contractors' Compliance to EMI/EMC Contractual/Tech Rqmts
Assess Adequacy and Validation of Models, Simulations Used
Assess Adequacy of Design Analyses, Trades and Contractors' Effectiveness to Design for Interoperability
Assess Contractors' V&V Procedures & Results: Analyses, Tests, Demos
Ensure Dissemination of EMI/EMC Technical Data Among Stakeholders
Assess Contractors' Compliance to EMI/EMC Req'ts
Review Contractors' Tech Data (Technical & Training Manuals, Test & Integration Procedures
Assess EMI/EMC Test & Demo Procedures, Monitor Test Activities, Assess Results
Ensure Contractors' EMI/EMC activities are integrated with other related Engineering
Ensure Dissemination of EMI/EMC Technical Data Among Stakeholders
Dissemination of IC Technical Data g Stakeholders

EMI/EMC Engineers' Contributions to Engineering Life Cycle Framework

Relationship to the SE Organization

The EMCE plans and executes the essential EMI/EMC engineering and engineering management efforts in an integrated and effective manner within the context and full support of the overarching Systems Engineering function. The EMCE ensures that their SED contributions are timely, adequate, consistent, and compliant. The EMCE ensures that their engineering contributions are channeled through the Systems Engineering *Analyses and Control* activity.

Systems Engineers manage the engineering process and activities depicted in Figure 3 while the EMCE contributes to this process. The EMCE supports concept and architecture development and analyses; modeling and simulation efforts; technology studies when potentially impacted by EMI/EMC challenges. The EMCE also develops/derives EMI/EMC related requirements and supports the requirements analyses and allocations process. EMCE participates in technical studies and solutions trades when EMI/EMC engineering is a factor. Additional responsibilities for the EMCE include assessing and proposing alternative mitigating actions or solutions. EMCE also provides design analyses contributions to determine the need for and the adequacy of EMI mitigation solutions, e.g. packaging designs, shielding, filtering, circuitry designs, etc. The EMCE works closely with the System Engineers performing interface and functional analyses to leverage EMI/EMC requirements. The EMCE also supports verification and validation planning and execution.

In performing the management and control function, the Systems Engineer effectively integrates all engineering functions through the full system life cycle. The EMCE ensures EMI/EMC technical contribution to the overall engineering advances and is appropriately applied through systematic control, collaboration and sharing across the organization. In addition, the EMI/EMC products are timed and applied by the other Specialty Engineers to perform their unique contributions, and must be provided to technical and program management for decision making.

Relationship to other SEDs

The EMCE SED relationship to other SEDs is summarized in Figure 1. EMCE interactions with the other engineering disciplines are critical to perform and integrate their engineering contributions to the system development efforts.

The EMCE must be knowledgeable with regards to EMI / energy emissions safety margins and the potential criticality of the effects of interference induced anomalies on the system and equipment in development. Interference safety margins are classified into the following three categories:

- Category I: Serious injury or loss of life, damage to property, major loss or delay of mission capability.
- Category II: Degradation of mission capability including any loss of autonomous operational capability.
- Category III: Loss of functions not essential to mission.

Hence, EMCE teams with the System Safety Engineers and Reliability Engineers to perform system hazards and failure analyses to determine items or functions when performed or whose failure could lead to a hazardous system state or degraded system performance state.

The EMCE works closely with Human Systems Integration to design systems that can be operated and maintained by users; and are habitable and safe with minimal EMI/EMC and occupational health hazards. When failure analyses and safety analyses results indicate potential hazards impacts due to EMI or hazardous energy emissions, the EMCE assists to determine alternative technology or design solutions and ensure attaining EMI/EMC requirements through collaboration with T&E for verification through analyses, demos, and tests.

The EMCE collaborates with the Survivability Engineering in performing complementary EMI analyses to support the survivability/vulnerability analyses. The EMCE also works in conjunction with the Logistics Engineers performing maintenance and sustainment analyses to identify and address EMI/EMC related issues or risks. When considering a system's capability to successfully operate with E3 in the EME, the EMCE must also collaborate with the Environmental Engineer to ensure compliance with the National Environmental Policy Act (NEPA), and in particular, any Environmental Impact Assessments (EIAs).

Tools Selection and Use

The EMCE considers effectiveness and efficiencies gained by selecting and using the best choice of EMI/EMC Engineering tools considering the EMI/EMC tool requirements.

Typical EMI/EMC Engineering Functions Requiring Tools
EMC analyses
EMC planning
Spectrum Supportability Risk Assessments

Engineering Activities and Products over the Life Cycle

EMC engineering involves the application of sound EM principles, Spectrum Management, technologies and design solutions to ensure interference-free operation, and clear concepts and doctrine that maximizes operational effectiveness. In recent times, the proliferation of worldwide emitters utilizing the EM spectrum poses additional challenges to the military in ensuring mission success in reference to EMC.

From a technical perspective, the EMCE must be involved very early in the acquisition process to ensure that the program's alternative systems concepts and eventually the preferred concept factors in implications of EMI. The following subsections delineate EMCE contributions to engineering activities and technical products by DoD acquisition phase.

MSA Phase – Technical Products Required	
SMC EMI/EMC Technical Products	**Contributions to Other Organizations' Products**
High level assessment proposed concepts & architectures	Operational Concepts; DoDAF CVs, OVs
Inputs & factors for concept, arch, technology studies, and trades	AoA Studies
EMI/EMC Req'ts	ICD
Roadmap and architectural inputs – Identification & mitigations of potential EMI	Stage 1 Spectrum Supportability Certification

1. **Materiel Solution Analysis.** During this phase, the EMCE may provide inputs to and support the Capabilities Based Assessment process and the JCIDS process to support the development of the joint operating, joint functional, and joint integrating concepts that are developed by the operating or using commands identify potential E3 impacts. EMCE may also support XR or Program Office efforts to develop the enabling or preferred system concept. The EMCE may also support the defining or refining of EMI/EMC related requirements to support ICD development while providing inputs to the Stage 1 Spectrum Supportability

Certification request for approval. Additionally, the EMCE contributes to the development of the required MS A technical products.

2. **Technology Development.** In the TD phase, the EMCE continues to provide inputs to and supports the JCIDS process. The EMCE also supports all the engineering activities highlighted within the box titled *Engineering Activities for System & Segment Development & Design* Figure 21 to commence system definition and development. The EMCE develops and contributes to development of the TD Phase technical products to include technology studies, preferred concept development, technology studies, requirements development, as well as SSRA and E3 control requirements in the Government's Statement of Work, Performance Specifications, and contract data requirements. EMCE continues to ensure that representation of EMI/EMC engineering inputs are integrated into various technical documentation including the ISP, test requirements in the TEMP, updating EMI/EMC inputs to the CDD, as well as the Stage 2 DD Form 1494 Spectrum Supportability Certification.

TD Phase – Technical Products Required	
SMC EMI/EMC Technical Products	**Contributions to Other Organizations' Products**
Assessment proposed concepts architectures, technologies	Operational Concepts; DoDAF CVs, OVs
Inputs & factors for concept, arch, technology studies, and trades	Inputs to CDD, AoA Studies
Dev & analyses of system & allocated EMI/EMC requirements	Stage 2 DD Form 1494 Spectrum Supportability Certification

3. **Engineering & Manufacturing Development.** The work involved in the EMD phase is a continuation of the work from the TD phase to include updates to the spectrun and E3 control requirements and ensure they are addressed in the Capability Production Document and flow to the defined system and allocated requirements. The EMCE continues to provide inputs to and supports the JCIDS process. EMCE supports all the engineering activities highlighted within the box titled *Engineering Activities for Detailed Design* Figure 21 to commence detailed systems definition and development. The EMCE develops and contributes to development of the EMD Phase technical products to include technology maturity assessments; EMI/EMC analyses; EMI/EMC system, allocated, and design requirements development; as well as SSRA and broader E3 control requirements in the Government's Statement of Work, Performance Specifications, and contract data requirements. The EMCE ensures process is in place to report, analyze, and mitigate hazards risk data during DT&E. The EMCE provides contributions to the development of the EMD phase technical products and, in particular, the CPD, TEMP, as well as in the submission for a Stage 3 Spectrum Supportability Certification request.

EMD Phase – Technical Products Required	
SMC EMI/EMC Technical Products	**Contributions to Other Organizations' Products**
Inputs to arch, technology eng trades; ISP; CVs, OVs, SVs, SvcVs, StdVs, AVs	Inputs to CPD
Inputs for performance and sustainment analyses	Inputs to operational assessments
Inputs to Eng Change reviews; EMI/EMC design requirements	Stage 3 Spectrum Supportability Certification
Inputs to system design, production, fielding, sustain docs	

4. **Production & Deployment, Operations & Support.** As in the previous phases, the EMCE continues to ensure that the design and meets the contractual EMI/EMC engineering requirements and that manufacturing, build and integration activities do not induce additional challenges and/or risks. The EMCE may have to conduct additional E3 analysis if any operational parameters are changed. The EMCE ensures the program appropriately addresses EMI/EMC issues in accordance with SMC Compliancy Standard, SMC-S-008, and provides contributions to the development of the P&D / O&S phase technical products, which includes the submission for a Stage 4 Spectrum Supportability Certification request.

P&D / O&S Phase – Technical Products Required	
SMC EMI/EMC Technical Products	**Contributions to Other Organizations' Products**
Inputs tech baseline engineering changes	Supportability assessment Rpt
Inputs to Test, Demo docs	Operational assessments contributions
Inputs to Transition & Fielding Docs	Stage 4 Spectrum Supportability Certification

EMI/EMC Engineers' Contributions to Program and Project Management

Each SMC program defines their business model and approach based primarily on program objectives, technical challenges, organizational structure, and required engineering planning including EMI/EMC engineering for cost-effective execution.

EMI/EMC control is a specialized function and must be assessed and demonstrated at the early stages of initial system concept development and throughout the systems life cycle. An Electromagnetic Control Plan is essential to a properly conceived system's EMC performance. The initial Electromagnetic Control Plan introduces the purpose, scope, application, update and revision, and applicable reference documents. Additionally, it frames the plans purpose, the program outline, organization, tasks, schedule and EMC analysis support. It provides a means for interference control approach, while addressing EMC criteria and techniques with electrical bonding criteria, electrostatic grounding requirements, grounding criteria, wiring, safety criteria, lightning protection criteria, circuit design criteria, and mechanical design.

In addition, an initial Electromagnetic Test Plan is developed. The Test Plan defines the items to be tested, procedures, methods and techniques to be used, resources required and time line definition compatible with the Program Office Integrated Master Schedule (IMS), TEMP and other program documents

The EMCE develops and implements the EMI/EMC engineering program planning to achieve Program Office EMI/EMC engineering objectives and requirements. The planning defines the EMI/EMC tasks and functions to be performed and products to be developed; timing of tasks, task outputs, resources (skills, tools, equipment, and completion criteria). The EMCE plans tasks to integrate EMI/EMC activities within the Program Office, between Contractors and stakeholders.

Execution of the EMCE planning is typically defined through an Operating Instruction which implements SMC and higher level instructions, policies, and directives. The EMCE provides full support to define the program and technical objectives where EMI/EMC challenges and risks are known or anticipated. The EMCE assists to establish the business model, develop program planning and schedules, and define and implement program processes. The EMCE ensures the EMI/EMC components of the program are appropriately represented in the program plans, program schedules, work breakdown schedules, and cost estimates. The EMCE also reports their technical performance and progress, and shares in the risk management responsibilities to identify, assess, and propose mitigating actions of EMI/EMC related risks. They also support the program manager's problem identification, resolution, and decision-making processes.

The EMCE supports the PMs in developing spectrum-dependent (S-D) systems/equipment to consider spectrum requirements and Electromagnetic Environmental Effects control early in the development process to ensure equipment can operate compatibly with other S-D equipment already in the intended operational environment. The EMCE contributes to the development of the program management products identified in the Table.

SMC Program Management Products
PMD
IMP, IMS, WBS
Technical progression and issues reporting
LC Cost Estimate (CARDs)
Processes (OIs)
Risk Management Inputs (SSRA)

Appendix Q – Parts Materials, and Processes Engineering

Parts, Materials, and Processes (PMP) engineering is a well-defined SMC discipline. PMP activities are performed over the lifecycle of a system. During concept and technology development, PMP is an integral engineering consideration to identify and mitigate PMP related risks and perform tradeoffs between system performance, technology advancements, PMP reliability, availability, producibility and ease of maintenance, and cost. During system development and design, PMP Engineers ensure all activities and processes are adequate for the application, selection, qualification, procurement, documentation and disposition of all parts, materials and processes required to implement the system design. This includes all flight, qualification, proto-qualification, and deliverable ground segment hardware.

PMP engineering involves three engineering disciplines: Parts / Components Engineers, Materials and Processes Engineers, and Contamination Control Engineers. A typical PMP program (SMC and Contractor participation) is depicted in Figure 22 below.

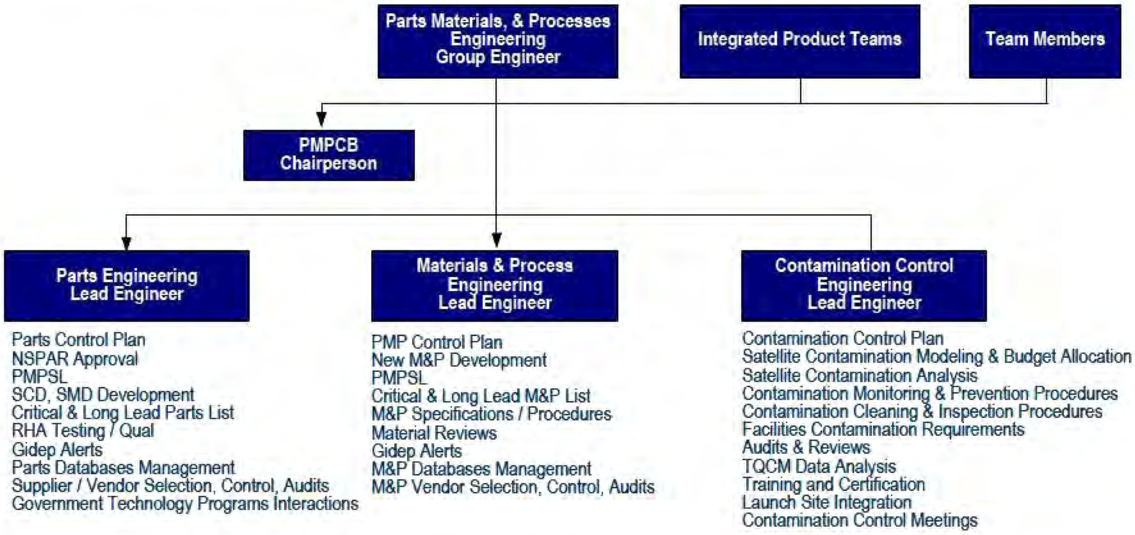


Figure 22 Typical Parts, Materials, and Processes Program

Instructions, guidance, and senior expert SMC Staff resources are available to assist the Program Office PMP Engineer stand-up and execute the essential PMP engineering activities for the Program Office. Much of the PMP Engineers' activities include implementation of the PMP *Selection and Control* program. A parts, materials, and processes selection and control program is vital to:

- Ensure integrated management and balanced technical decisions regarding selection, application, acquisition, control, and standardization of parts, materials, and processes
- Improve acquisition and qualification of piece parts, materials, and critical processes that meet system requirements
- Implement the reliability program at the PMP level to reduce PMP failures at all levels of integration, assembly, test, and operations
- Reduce program life-cycle costs

PMP is accomplished by a team of PMP Engineers, Systems Engineers, Quality Engineers, Reliability Engineers, Design Engineers, Test Engineers, and others that understand their responsibilities to collaborate to achieve the PMP objectives and requirements. The full intent is to address PMP related risks as early as possible in the product lifecycle to provide greater opportunities to make balanced decisions regarding PMP selections. As design decisions are made and the development efforts transition to production and fielding, PMP related design changes may be orders of magnitude more expensive. An effective PMP program seeks to minimize the use of nonstandard parts, hazardous materials, and critical processes with the end result of minimizing total life-cycle costs. The PMP Engineer conducts or oversees the selection process factoring system reliability, manufacturing quality controls, operational environments, and parts obsolescence mitigations due to Diminishing Manufacturing Sources and Material Shortages (DMSMS).

The PMP Engineer plans and executes the essential PMP Engineering and management efforts in an integrated and effective manner to ensure that each PMP contribution is timely, adequate, consistent, and compliant. The PMP Engineer ensures that their engineering contributions are also channeled through the Systems Engineering *Analyses and Control* activity.

Applicable governance, standards, and guidance

Policy, directives, and instructions that mandate SMC PMP engineering related program requirements are included in a wide range of mandates including those providing requirements for acquisition, Systems Engineering, Reliability, T&E, Quality Assurance, and others.

The DoDI 5000.02 directs the establishment of a viable reliability strategy and growth program as an integral part of design and development. System reliability is achieved, in part, through rigorous parts design practices, selection, qualification, and process control to optimize yield and minimize workmanship issues. DoDI 5000.02 and DoDI 5000.67 also require a long-term DoD corrosion prevention and control strategy that supports reduction of total cost of system ownership. ACAT I programs document its strategy in a Corrosion Prevention Control Plan. The Plan is required at Milestones B and C. Corrosion assessments are performed throughout program design and development activities with trades made through a transparent assessment of alternatives.

AFI 63-1201 requires the use of Program Office ***approved parts only*** in the system. Hence the Program Office must be an integral participant and approval authority for the system parts selection process. The SMC Systems Engineering Standard SMC-S-001 also provides requirements for the PMP Engineer:

- Detailed environmental parameters are defined/derived that impact parts performance.
- Parts/materials engineering/design requirements are allocated, baselined, and traceable to system level performance requirements, including risk assessments.
- Functional parts parameters are baselined and captured in detailed technical/procurement specifications, e.g., Specification Control Drawings (SCDs), Standard Microcircuit Drawings (SMDs). [Feb 13, 2011, John IC's comment: At the top of page 217 there is a bullet - Functional Parts Parameters etc this needs to be deleted and rewritten.SMC-S-009 /010 designate the Space Qualified Baseline for parts Active and Passive and materials , there are detailed rules for Parts and Material selection. Use of SCDs and/or SMDs is a last resort. Reference to Parts engineers should include Contractors Parts Engineers.]

- Technology development plans are executed and technology readiness levels demonstrate products/technology suitable for system application and support program development schedules.
- Qualified sources of supply and industrial base assessment results are addressed.
- Space systems radiation hardening design solutions are established.

The SMC PMP standards SMC-S-009 through -011 provide the detailed Contractors' PMP program requirements. These standards are intended to be appropriately tailored and placed on SMC development contracts for Contractor compliance. Table 22 below identifies the significant governance, standards, and guidance which generally require SMC compliance for PMP Engineering.

Table 22 Governance, standards, and guidance that shape the Parts Materials, and Processes Engineering discipline

Document No	Governance Title	Issue
DoDI 5000.02	Operation of the Defense Acquisition System	08 Dec 08
CJCSM 3170.01	Operation of the Joint Capabilities Integration and Development System	24 Jun 03
DoDI 5000.67	Prevention & Mitigation of Corrosion on DoD Military Equipment and Infrastructure	25 Jan 08
DoDI 4140.57	DoD Replenishment Parts Purchase or Borrow (DoD RPPOB) Program	30 May 08
Document No	**Standards Title**	**Issue**
ASTM E 1548-2009	Standard Practice for Preparation of Aerospace Contamination Control Plans	2006
ANSI/AIAA R-100A-2001	Recommended Practice for Parts Management	2001
SMC-S-001	Systems Engineering Requirements and Products	12 July 10
SMC-S-009	PMP Control Program for Space and Launch Vehicles	12 Jan 09
SMC-S-010	Technical Requirements for Electronic Parts, Materials, and Processes For Space and Launch Vehicles	12 Jan 09
SMC-S-011	PMP Control Program for Expendable Launch Vehicles	13 Jun 08
Document No	**Guidance Title**	**Issue**
MIL-HDBK-512	Parts Management Handbook	
TOR-2006(8583)-5235	PMP Control Program for Space and Launch Vehicles	Nov 06
CPATS	Critical Process Assessment Tool – PMP	23 Sep 06
SD-19	Parts Management Guide	Sep 09

PMP Engineers' Contributions to the Acquisition Life Cycle Framework

The DoD acquisition life cycle is defined by DoDI 5000.02. PMP Engineering contributions over this life cycle are best represented within the phase of acquisition.

Figure 23 provides the acquisition life cycle framework within which PMP Engineers perform as well as the products that the PMP Engineers develop or contribute to their development. This figure along with SMCI 62-1201, provide the requirements to perform PMP engineering planning, support pre and post contract award acquisition activities, and perform PMP engineering and management across the system lifecycle. SMC Program Offices establish and implement PMP Engineering program strategies and objectives consistent with the tenets of applicable policies, SMC acquisition objectives, and program objectives. The Program Office develops, attains approval for, and implements PMP Engineering (parts and materials selection & control, process development & control, Corrosion prevention) planning into the Systems Engineering Plan (SEP) and higher level integrated planning (e.g., IMP) in accordance with current DoD policy. This planning is firmly based on program and technical objectives, strategies, DoD mandates, and instructions. The planning sufficiently defines the PMP program to achieve the PMP engineering and overall program objectives and requirements; specifies tasks and functions to be performed, timing of tasks, resources required, and products to be developed; forms the basis for the development of the program PMP engineering Instruction (OI). The PMP OI may be contained within the SE OI.

The PMP engineering planning and OI are then reflected appropriately in the WBS, IMS, and other program documents that address PMP engineering related elements. The SMC Program Office System PMP planning (usually contained in the SEP and the detailed PMP engineering program planning) and OI are also based upon the appropriate program-approved life cycle. The following subsections delineate PMP engineering contributions to acquisition activities and products by DOD acquisition Phase. Refer to ASTM E 1548-2009, Standard Practice for Preparation of Aerospace Contamination Control Plans and ANSI/AIAA R-100A-2001, Recommended Practice for Parts Management for a more complete list of PMP Engineering activities and products that are prepared by the Program office and their Contractors.

1. **Materiel Solution Analysis.** During this phase the PMP Engineer provides inputs to and supports most program acquisition activities to include the development of the acquisition strategy, inputs to the cost estimates, solicitation/RFP development for Contractor studies, and proposal evaluation activities. The PMP Engineer also contributes to the development of the MSA Phase acquisition products.

MSA Phase – SMC Acquisition Products
PMD
ASP, TDS, DMS, TES
LC Cost Estimate
RFP inputs (PMP related constraints and requirements; High level assessments of concepts
APB, CCA
SEP, LCMP, ISP

2. **Technology Development.** The PMP Engineer provides inputs to and supports all program acquisition activities to include the development of the acquisition strategy, updates to the cost model and development of the Cost Analysis Requirements Description (CARD), solicitation/RFP development and proposal evaluation activities. The PMP Engineer identifies other related contract requirements for PMP selection, control, and qualification, Long Lead (LL) purchases to meet PMP Engineering objectives and required SMC PMP requirements. The PMP Engineer also contributes to the development and updates to the TD Phase acquisition products.

TD Phase – SMC Acquisition Products
Updates to ASP, TDS, DMS
LC Cost Estimate Update / CARD Development
RFP: PMP objectives in the SOO; PMP related tasks in SOW, PMP data products in CDRLs; SMC- PMP standards - tailored
APB: PMP objectives & related concept descriptions
Detailed PMP and corrosion prevention planning; Inputs to SEP, LCMP, TEMP
Initial PMSDL, Critical Materials and Processes Lists

3. **Engineering & Manufacturing Development.** The PMP Engineer provides inputs to and supports all program acquisition activities to include updates to the acquisition strategy and updates to the cost model to reflect the actual technical solutions determined and updates to the CARD. PMP Engineer supports the solicitation/RFP development and proposal evaluation activities which include providing the technical inputs including technical requirements, compliance standards, engineering approaches, incentives, and warranty programs to meet program objectives. The PMP Engineer identifies other related contract requirements for PMP selection, control, and qualification, parts and materials purchases, parts obsolescence avoidance, sparing, etc. to meet PMP engineering objectives and required

EMD Phase – SMC Acquisition Products
Updates to ASP, TDS, DMS
CARD Update
RFP: PMP objectives in the SOO; PMP related tasks in SOW, PMP data products in CDRLs; SMC- PMP standards - tailored
Detailed PMP and corrosion prevention planning; Inputs to SEP, LCMP, TEMP
PMSDL, Critical Materials and Processes Lists

SMC PMP requirements per the standards cited in the *standards* table above. PMP Engineer also contributes to the development and updates to the EMD Phase acquisition products.

4. **Production & Deployment, Operations & Support.** The PMP Engineer provides inputs to and supports all program acquisition activities to include updates to the acquisition strategy and updates to the cost model to reflect the actual technical solutions determined and updates to the CARD. The PMP Engineer supports the solicitation/RFP development and proposal evaluation activities.

P&D / O&S Phase – SMC Acquisition Products
Updates to ASP, TDS, DMS
RFP: PMP objectives in the SOO; PMP related tasks in SOW, PMP data products in CDRLs; SMC- PMP standards - tailored
APB: PMP objectives & related concept descriptions
Detailed PMP and corrosion prevention planning; Inputs to SEP, LCMP, TEMP
CARD update

The PMP Engineer identifies other related contract requirements for PMP selection; control; qualification; parts and materials purchases; parts obsolescence avoidance; manufacturing controls, inspections, testing; sparing, etc. to meet PMP engineering objectives and required SMC PMP requirements per the standards cited in the standards table above. The PMP Engineer identifies other contract requirements for field test & demo requirements; field performance and sustainment analyses.

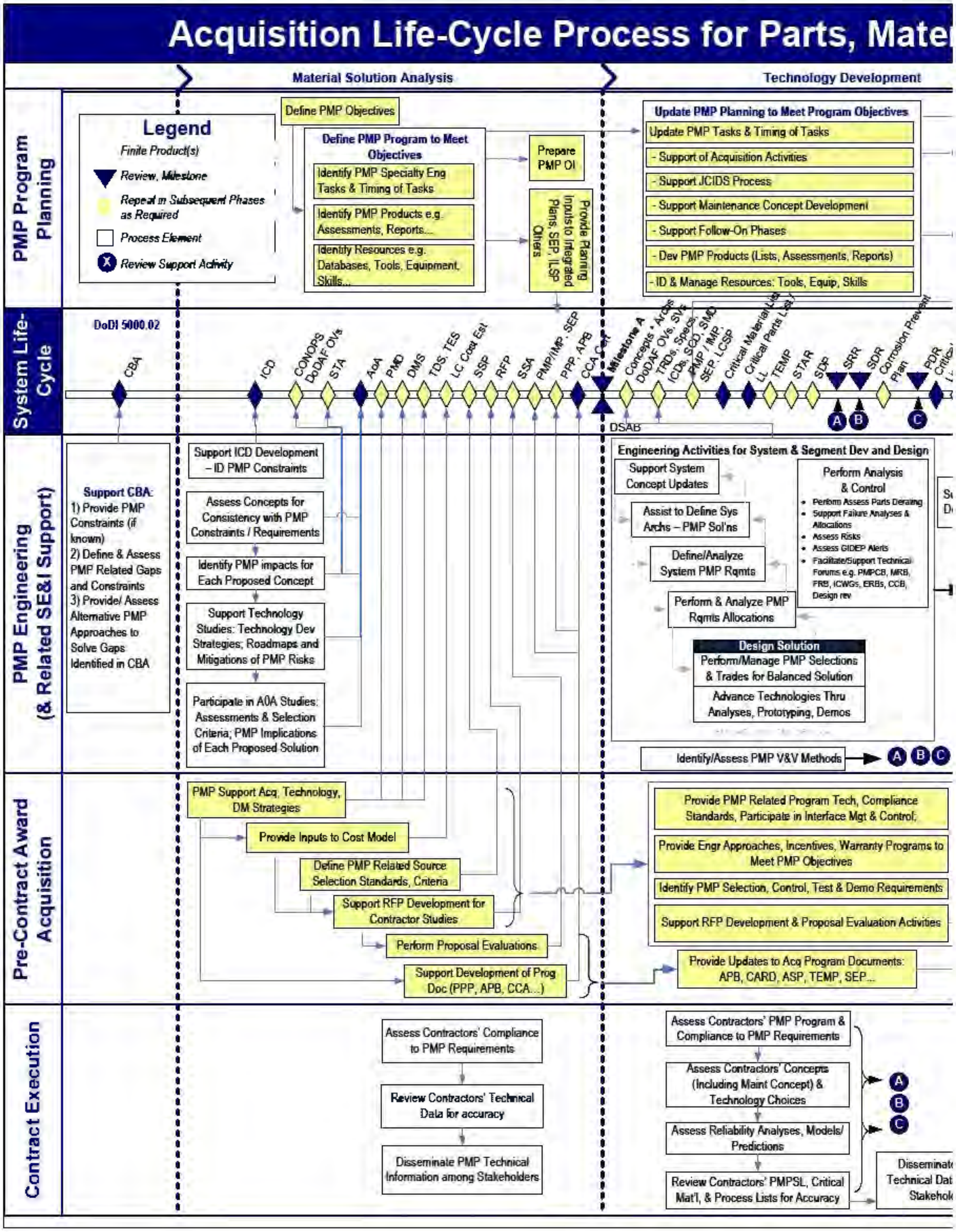
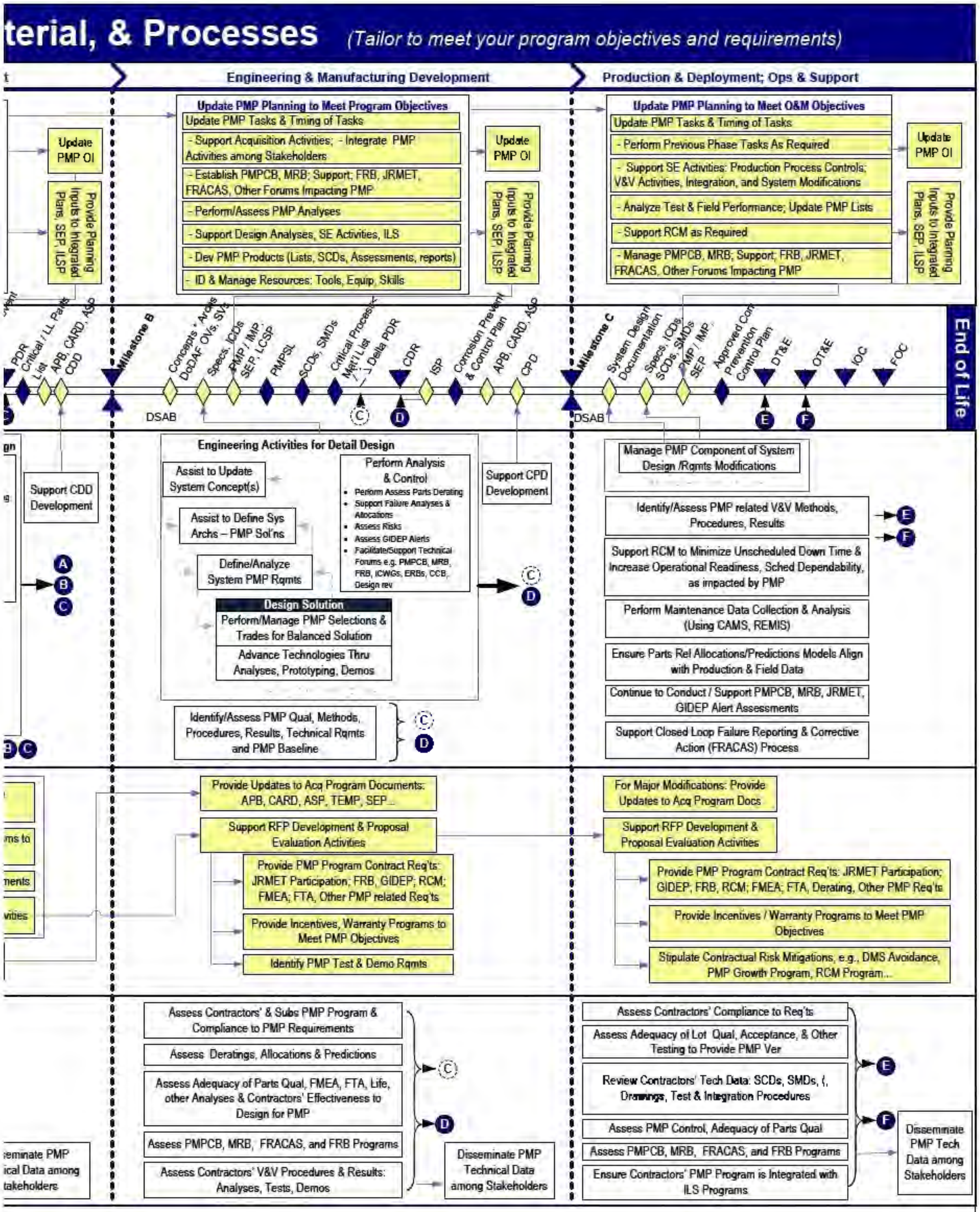


Figure 23 Acquisition life cycle process for SMC Parts, Materials, and Processes


terial, & Processes
(Tailor to meet your program objectives and requirements)
Engineering & Manufacturing Development
Production & Deployment; Ops & Support
Update PMP Planning to Meet Program Objectives
Update PMP Tasks & Timing of Tasks
- Support Acquisition Activities; - Integrate PMP Activities among Stakeholders
- Establish PMPCB, MRB; Support; FRB, JRMET, FRACAS, Other Forums Impacting PMP
- Perform/Assess PMP Analyses
- Support Design Analyses, SE Activities, ILS
- Dev PMP Products (Lists, SCDs, Assessments, reports)
- ID & Manage Resources: Tools, Equip, Skills
Update PMP OI
Provide Planning Inputs to Integrated Plans, SEP, ILSP
Update PMP Planning to Meet O&M Objectives
Update PMP Tasks & Timing of Tasks
- Perform Previous Phase Tasks As Required
- Support SE Activities: Production Process Controls; V&V Activities, Integration, and System Modifications
- Analyze Test & Field Performance; Update PMP Lists
- Support RCM as Required
- Manage PMPCB, MRB; Support; FRB, JRMET, FRACAS, Other Forums Impacting PMP
Update PMP OI
Provide Planning Inputs to Integrated Plans, SEP, ILSP
PDR
Critical / LL Parts List
APB, CARD, ASP, CDD
Milestone B
Concepts * Archs DoDAF OVs, SVs
Specs, ICDs
PMP / IMP, SEP, LCSP
PMPSL
SCDs, SMDs
Critical Processes
Mat'l List
Delta PDR
CDR
ISP
Corrosion Prevent & Control Plan
APB, CARD, ASP
CPD
Milestone C
System Design Documentation
Specs, ICDs, SCDs, SMDs
PMP / IMP, SEP
Approved Corr Prevention Control Plan
DT&E
OT&E
IOC
FOC
End of Life
DSAB
DSAB
Support CDD Development
Engineering Activities for Detail Design
Assist to Update System Concept(s)
Assist to Define Sys Archs – PMP Sol'ns
Define/Analyze System PMP Rqmts
Perform Analysis & Control
• Perform Assess Parts Derating
• Support Failure Analyses & Allocations
• Assess Risks
• Assess GIDEP Alerts
• Facilitate/Support Technical Forums e.g. PMPCB, MRB, FRB, ICWGs, ERBs, CCB, Design rev
Design Solution
Perform/Manage PMP Selections & Trades for Balanced Solution
Advance Technologies Thru Analyses, Prototyping, Demos
Support CPD Development
Identify/Assess PMP Qual, Methods, Procedures, Results, Technical Rqmts and PMP Baseline
Manage PMP Component of System Design /Rqmts Modifications
Identify/Assess PMP related V&V Methods, Procedures, Results
Support RCM to Minimize Unscheduled Down Time & Increase Operational Readiness, Sched Dependability, as impacted by PMP
Perform Maintenance Data Collection & Analysis (Using CAMS, REMIS)
Ensure Parts Rel Allocations/Predictions Models Align with Production & Field Data
Continue to Conduct / Support PMPCB, MRB, JRMET, GIDEP Alert Assessments
Support Closed Loop Failure Reporting & Corrective Action (FRACAS) Process
Provide Updates to Acq Program Documents: APB, CARD, ASP, TEMP, SEP...
Support RFP Development & Proposal Evaluation Activities
Provide PMP Program Contract Req'ts: JRMET Participation; FRB, GIDEP; RCM; FMEA; FTA, Other PMP related Req'ts
Provide Incentives, Warranty Programs to Meet PMP Objectives
Identify PMP Test & Demo Rqmts
For Major Modifications: Provide Updates to Acq Program Docs
Support RFP Development & Proposal Evaluation Activities
Provide PMP Program Contract Req'ts: JRMET Participation; GIDEP, FRB, RCM; FMEA; FTA, Derating, Other PMP Req'ts
Provide Incentives / Warranty Programs to Meet PMP Objectives
Stipulate Contractual Risk Mitigations, e.g., DMS Avoidance, PMP Growth Program, RCM Program...
Assess Contractors' & Subs PMP Program & Compliance to PMP Requirements
Assess Deratings, Allocations & Predictions
Assess Adequacy of Parts Qual, FMEA, FTA, Life, other Analyses & Contractors' Effectiveness to Design for PMP
Assess PMPCB, MRB, FRACAS, and FRB Programs
Assess Contractors' V&V Procedures & Results: Analyses, Tests, Demos
Disseminate PMP Technical Data among Stakeholders
Assess Contractors' Compliance to Req'ts
Assess Adequacy of Lot Qual, Acceptance, & Other Testing to Provide PMP Ver
Review Contractors' Tech Data: SCDs, SMDs, (, Drawings, Test & Integration Procedures
Assess PMP Control, Adequacy of Parts Qual
Assess PMPCB, MRB, FRACAS, and FRB Programs
Ensure Contractors' PMP Program is Integrated with ILS Programs
Disseminate PMP Tech Data among Stakeholders

PMP Engineers' Contributions to the Engineering Life Cycle Framework

Relationship to the SE Organization

The PMP Engineer plans and executes the essential PMP engineering and engineering management efforts in an integrated and effective manner within the context and full support of the overarching Systems Engineering function. The PMP Engineer ensures that their SED contributions are timely, adequate, consistent, and compliant. The PMP Engineer ensures that their contributions are channeled through the Systems Engineering *Analyses and Control* activity.

Systems Engineers manage the engineering process and activities depicted in Figure 3 while the PMP Engineer contributes to this process. PMP Engineers support concept and architecture development and analyses; modeling and simulation efforts; technology studies when potentially impacted environmental challenges. The PMP Engineers develop/derive the PMP related requirements and support the requirements analyses and allocations process. They also participate in technical studies and technical solutions trades when PMP is potentially impacted. They provide design analyses contributions to determine DMSMS / parts obsolescence issues; parts performance, reliability, producibility, and quality assurance concerns, and other potential risks or concerns that impact PMP. They assess and propose alternative mitigating actions or solutions. The PMP Engineer also works closely with the System Engineers performing technology studies and assessments, requirements analysis, reliability and hazards analysis, benign and hostile environments analysis. The PMP Engineer also supports the integration and verification and validation planning and execution.

In performing the management and control function, the Systems Engineer effectively integrates all engineering functions through the full system life cycle. The PMP Engineer ensures their technical contribution to the overall engineering advances and is appropriately applied through systematic control, collaboration and sharing across the organization. For example, their activities and products are timed to coincide with architectural trades, design trades, reliability analyses. In addition the Environmental products are timed and applied by the other Specialty Engineers to perform their unique contributions, and must be provided to technical and program management for decision making. The PMP Engineer oversees the Contractors' PMP selection and control process.

Relationship to other SEDs

The PMP Engineer SED relationship to other SEDs is summarized in Figure 1. PMP Engineer interactions with the other SEDs are critical to perform and integrate their engineering contributions to the system development efforts.

PMP Engineers team with the Reliability Engineers to perform analyses to determine reliability allocations to the piece part level, piece part yields, material life limitations material hazards, and parts qualification testing requirements. When failure analyses results indicate the need to reallocate reliability parameters at the parts level, the PMP Engineer assists to adjust reliability allocations and ensure confidence in attaining system level requirements through analyses, demo, and test.

PMP Engineers team with Quality Assurance and Quality Engineers to determine component manufacturing controls to maintain quality conformance levels, establish acceptable yield rates, and minimize rework and repairs.

The PMP Engineer works closely with the Logistics Engineers defining the maintenance concept, and performing maintenance and sustainment analyses to identify and address sparing needs and requirements.

Tools Selection and Use

The PMP Engineer considers effectiveness and efficiencies gained by selecting and using the best choice of PMP engineering tools considering the PMP tool requirements possibly for hazards analyses, information sharing, automated data exchanges with other tools, and other considerations.

Typical PMP Engineering Functions Requiring Tools
PMPSL Management
SCD, SMD development, coordination and approval
Pre-selection parts & materials database
Analytical tasks

Engineering Activities and Products over the Life Cycle

Design engineering of our space assets depends on the criticality, type, and application of the system being acquired by SMC. Parts and material design and selections for space vehicle and launch vehicle require unique qualifications for launch and space environments. Transporting, deploying, and operating in space requires highly robust piece parts. Piece parts / components must be designed to perform in extreme hot and cold temperatures and harsh space environments that include energetic particle radiation, plasmas, micro-particles, and contamination. Hence, piece parts / components undergo environmental testing requires highly specialized facilities and equipment to simulate the severe launch and operational environments of space. Parts and material design and selections for our ground systems take into account field deployable and located and operated in any terrain and climate conditions and are usually air and ground transportable or placed in a more benign permanently fixed site.

As a result, a comprehensive PMP program is required to avoid risks associated with PMP development, design, selection, and control. The contractor is usually required to prepare and submit a PMP Program Plan to the Program Office with their proposal or shortly following contract award. The plan defines the overall scope and activities required in order to accomplish the technical, schedule and cost requirements defined in the contract. The activities in the PMP Program plan include but are not limited to:

- Roles, responsibilities and interfaces with other program and functional organizations
- Requirements derivation and flow-down
- Parts and materials selection, analysis (design margin, derating, stress analysis, etc.), documentation, procurement and qualification
- New technology insertion and qualification
- Engineering drawing review and signoff
- As-Designed and As-Built PMP Lists
- PMP Risk Management
- Subcontractor and Supplier selection, qualification and monitoring
- PMP Lot Traceability and Control
- PMP inspection, handling, ESD control, shelf life control, and re-qualification
- Discrepant PMP disposition and tracking
- Destructive Physical analysis

- Corrosion Prevention and Control
- Contamination Prevention and Control
- Radiation Hardness Assurance and Space Environmental Analysis, Qualification Testing and Lot Acceptance Testing
- GIDEP participation

The PMP Engineering Group (depicted in Figure 22 above) typically includes the Program Office PMP Engineer, Contractor(s) PMP Leads, and subject matter representation. The PMP Engineering Group is chartered to implement and operate the Parts, Materials and Processes Control Board (PMPCB). The purpose of the PMPCB is to perform PMP selection; define specification, qualification, and procurement requirements; review, maintain and track changes to the Parts, Materials and Processes Selection List (PMPSL); disposition discrepant or suspect PMP; and assess, identify, mitigate, track and report on PMP risks for the entire program. The PMP representative from the program office is a member of the PMPCB and an active participant.

The PMPCB coordinates all PMP across all program organizations (both internal to the contractor and their subcontractors, suppliers and vendors). The PMPCB is designed to provide both horizontal and vertical lines of communications by allowing the participants to identify concerns, issues and problem areas, quickly determining their impact and informing others within the program organization including the program office. Also, lessons-learned for one organization can be applied to other organizations to reduce overall development time and reduce acquisition costs. With new technologies and high product obsolescence as well as emphasis on process validation as well as product test and qualification, it is very important that past experiences and lessons-learned are taken in consideration.

Consideration is also given to the consequences resulting from inappropriate requirements translation and implementation:

- Requirements that have been inappropriately specified for the technology selected. During the process of vendor selection, contractors may receive a wide range of exceptions that might ultimately result in either cost and/or schedule delays due either to inability to manufacture an item or high yield loss impacts. In addition, the probability of high rate re-work during the manufacturing phase due to system level failures that develop could add additional costs and schedule delays to a program. If the requirements are not completely understood or improperly implemented, effective corrective action and proper risk mitigation cannot be performed.
- Requirements have been understood and correctly specified but the vendor verification process has not been properly carried out. This situation puts the parts and/or materials stocked for the program in jeopardy and raises the probability of high rate re-work occurring during the manufacturing phase due to system level failures causing additional costs and schedule delays to the program. If the requirements have been understood and specified, it is easier to specify and carry out corrective action; however, the program may incur significant cost and schedule impacts.

A typical example is the present European Union Legislation and Regulation mandate to have electronic manufacturers "lead-free" by July 1, 2006. To be compliant with the European Union's prohibition of lead (and five other substances), electronics manufacturers are considering other materials that might meet stipulated solderability requirements. One such material commonly used today is pure tin. This is an excellent choice in most instances but in the case of space applications it is not an acceptable choice. Within the environment of space, pure tin, pure zinc, and pure lead are known to experience metallic growths that both look like and are called "whiskers". The growths of these metallic whiskers have in previous space systems caused short circuits within the delicate electronic assemblies.

PMP's implementation and integration within the other specialty disciplines varies consistent with contractor's organizational structure and each program phase. The actual integration and requirements decomposition process for each physical element within each program phase forms the contractor's proposed systemic approach to implementation of Mission-need PMP Program Requirements.

An effective PMP Program typically defines two levels of implementation and performance. The first level constitutes the contractor's internal PMP Process activities. The second level constitutes the contractor's proposed control and flow-down of PMP requirements to their outside suppliers or subcontractors and activities, to ensure uniform PMP Program implementation.

For space programs, an Integrated Program Team or the Parts, Materials, and Processes Board (PMPCB) are traditionally established as the vehicle for PMP process integration and interface with all necessary disciplines and control of outside vendors and subcontractors throughout all program phases.

The following subsections delineate the PMP Engineer's contributions to the engineering activities and products by DOD acquisition Phase. Refer to ASTM E 1548-2009, Standard Practice for Preparation of Aerospace Contamination Control Plans and ANSI/AIAA R-100A-2001, Recommended Practice for Parts Management for a more complete list of PMP Engineering activities and products that are prepared by the Program office and their Contractors.

1. **Materiel Solution Analysis.** During this phase the PMP Engineer may provide inputs to and support the Capabilities Based Assessment process and the JCIDS process. The PMP Engineer evaluates proposed concepts and architectures to identify and assess implications of technologies and associated components and materials, and provides recommendations for each alternative. The PMP Engineer assists to define / refine PMP related strategies, technologies, and requirements to support ICD development and possibly system requirements document, e.g., TRD development. The PMP Engineer also contributes to the development of the MSA Phase technical products.

MSA Phase – Technical Products Required	
SMC PMP Technical Products	**PMP Contributions to Other Organizations' Products**
High level assessment of proposed concepts, architectures, technologies	Operational Concepts
PMP engineering inputs and factors for concept, architecture, technology studies, and trades	AoA Studies
PMP C (draft)	Initial Capabilities Doc (ICD) Dev

2. **Technology Development.** During this phase the PMP Engineer continues to provide inputs to and supports the JCIDS process. The PMP Engineer also supports all the engineering activities highlighted within the box titled Engineering Activities for System & Segment Development & *Design* Figure 23 to commence detailed systems definition and development. The PMP Engineer defines the requirements for a PMP program for the selection. control. and qualification. long lead. etc to meet PMP engineering objectives and SMC PMP requirements. PMP Engineer develops and contributes to development of the TD Phase technical products.

TD Phase – Technical Products Required	
SMC PMP Technical Products	**PMP Contributions to Other Organizations' Products**
Inputs to System Concepts	Operational Concepts
Factors for Studies/ Trades	Operational Assessments
PMP Tech Req'ts, TRD, Specifications, ICDs, Standards Selection/ Tailor	Capabilities Development Doc (CDD)
Prelim Parts and materials list	
Critical Processes list	
PMP related analyses	

3. **Engineering & Manufacturing Development.** The PMP Engineer continues to provide inputs to and supports the JCIDS process. The PMP Engineer supports all the engineering activities highlighted within the box titled Engineering Activities for Detailed Design Figure 23 to commence detailed systems definition and development. The PMP Engineer defines the requirements for and implements a PMP program for the selection. control. and qualification. parts and materials purchases. parts obsolescence avoidance. sparing. etc. to meet PMP engineering objectives and required SMC PMP requirements per the standards cited in the *standards* table above. The PMP Engineer provides inputs to and supports the JCIDS process. The PMP Engineer develops and contributes to the development of the EMD Phase technical products.

EMD Phase – Technical Products Required	
SMC PMP Technical Products	**PMP Contributions to Other Organizations' Products**
Technical Studies/ Trades inputs	Operational Concepts
System Tech Req'ts, TRD, Spec, ICDs, SCDs, SMDs; PMP requirements flow-down / allocations	Operational Assessments
Inputs to system design, production, fielding, sustain docs	Capabilities Production Doc (CPD)
Material review inputs; GIDEP review and impact assessments	
Parts derating assessment inputs	
Test, Demo assessments	
DPA assessments	
PMPSL	
GIDEP Assessments	

4. **Production & Deployment, Operations & Support.** The PMP Engineer continues to ensure the design meets contractual PMP requirements and manufacturing. build and integration activities do not induce additional PMP related risks. The PMP Engineer ensures the PMP program appropriately addresses full lifecycle requirements for sparing. manufacturing sources. and preplanned product improvements. The PMP Engineer develops and contributes to the development of the P&D / O&S Phase technical products.

P&D / O&S Phase – Technical Products Required	
SMC PMP Technical Products	**PMP Contributions to Other Organizations' Products**
Inputs tech baseline engineering changes; finalized SCDs, SMDs	Supportability assessment Rpt Contribution
Material review inputs; GIDEP review and impact assessments	Operational Assessments Contributions
Parts derating assessment inputs	Transition & Fielding Docs
Test, Demo assessments	
PMPSL updates	
GIDEP Assessments	

PMP Engineers' Contributions to Program and Project Management

Each SMC program defines their business model and approach structure based primarily on their program objectives, program and technical challenges, organizational structure, as well as program and engineering planning (SEP plus detailed PMP planning and corrosion prevention planning.)

The PMP Engineer develops and implements the PMP engineering program planning to achieve Program Office PMP objectives and requirements. The planning defines the PMP tasks and functions to be performed and products to be developed; timing of tasks, task outputs, resources (skills, tools, equipment, and completion criteria). The PMP Engineer plans tasks to integrate PMP activities within the Program Office, between Contractors and stakeholders. The PMP Engineer plans the tasks to establish and manage PMP selection and controls; conduct material, GIDEP, and other PMP review forums; support SE&I activities, risk management, integration, and system modifications; coordinate the PMP planning with SMC Staff PMP Engineering office, integrate PMP Engineering planning with other functional and acquisition plans (i.e. SEP, ASP, LCMP).

Execution of the PMP Engineer planning is typically defined through an Operating Instruction which implements SMC and higher level instructions, policies, and directives. The PMP Engineer provides full support to define the program and technical objectives where PMP challenges and risks are known or anticipated. The PMP Engineer assists to establish the business model, develop program planning and schedules, and define and implement program processes. The PMP Engineer ensures the PMP components of the program are appropriately represented in the program plans, program schedules, work breakdown schedules, cost estimates. The PMP Engineer also reports their technical performance and progress. The PMP Engineer shares in the risk management responsibilities to identify, assess, and propose mitigating actions of PMP related risks. They also support the program manager's problem identification, resolution, and decision-making processes.

The PMP Engineer contributes to the development of the program management products identified in the Table.

SMC Program Management Products
PMD
SEP, IMP, IMS, WBS
Decision-making & problem solving inputs
Technical progression and issues reporting
LC Cost Estimate (CARDs)
Processes (OIs)
Risk Management Inputs

Appendix R – Information Assurance Engineering

DoD defines Information Assurance (IA) as "measures that protect and defend information and information systems by ensuring their availability, integrity, authentication, confidentiality, and non-repudiation. This includes providing for the restoration of information systems by incorporating protection, detection, and reaction capabilities (CNSSI No. 4009)." All SMC programs classified as National Security Space Systems (NSS) are required to comply with DoDD 8500.01. The Information Assurance Manager (IAM) or the IA Engineer (IAE), appointed by the acquisition program manager, supports the responsibility to stand-up and execute the IA program. IAM or IAE can be the same individual, especially for smaller programs, and in the following description will be treated interchangeably. This SED describes necessary tasks and products, the policy from which they are derived, their relationship to the acquisition framework, and the engineering details one should consider in working towards effective IA defenses-in-depth in a net-centric environment.

Applicable governance, standards, and guidance

Table 23 below identifies the significant governance, standards, and guidance, which generally requires SMC compliance for IA.

Table 23 Governance, standards, and guidance that shape the Information Assurance Engineering discipline

Document No	Governance Title	Issue
DoDD 5000.01	Defense Acquisition System, E1.1.9. Information Assurance	current as of 20 Nov 07
DODI 5000.02	Operation of the Defense Acquisition System,, "Title 40/Clinger Chen Act (CCA)" Compliance	08 Dec 08
National Security Directive 42	National Policy for the Security National Security Telecommunications and Information Systems	05 Jul 90
Director of Central Intelligence Directive (DCID) 6/3	Protecting Sensitive Compartmented Information Within Information Systems	05 Jun 99
CNSSP-12	National Information Assurance Policy for Space Systems Used to Support National Security Missions	20 Mar 07
DoDD 8500.01E	Information Assurance (IA)	24 Oct 02
DoDI 8500.2	Information Assurance (IA) Implementation	06 Feb 03
DoDI 8580.1	Information Assurance (IA) in the Defense Acquisition System	09 Jul 04
DoDD 8581.01	Information Assurance (IA) Policy for Space Systems	08 Jun 10
DoDD 8570.01	Information Assurance Training, Certification, and Workforce Management	23 Apr 07
AFPD 63-17	Technology and Acquisition Systems Security Program Protection	26 Nov 01
Document No	**Standards Title**	**Issue**
NIST SP 800.53	Recommended Security Controls for Federal Information Systems and Organizations (Joint Task Force Transformation Initiative)	Aug 09
NIST SP 800-48	Guide to Securing Legacy IEEE 802.11 Wireless Networks	Jul 08
NIST SP 800-123	Guide to General Server Security	Jul 08
Document No	**Guidance Title**	**Issue**
DoDI 8510.01	DoD IA Certification and Accreditation Process (DIACAP)	28 Nov 07
-	DIACAP Knowledge Service at https://diacap.iaportal.navy.mil	https://diacap.iaportal.navy.mil
CNSSI No. 4009	National Information Systems Security Glossary revised	Jun 06
DoD 5220.22-M	National Industrial Security Program Operating Manual (NISPOM)	28 Feb 2006
-	DASD for Cyber, Identity, and Information Assurance Strategy	Aug 09
Defense Acquisition Guidebook (DAG)	DAG, Chapter 7: Acquiring Information Technology, Including National Security Systems, Section 7.5 Information Assurance	Current at https://dag.dau.mil/

DISA STIGs	Defense Information Systems Agency (DISA) Security Technical Implementation Guides (STIG) – various IA subjects	various
CJCSI 6212.01E	Interoperability and Supportability of Information Technology and National Security Systems	18 Dec 08

IA Engineers' Contributions to the Acquisition Life Cycle Framework

The SMC program IAE supports implementation of statutory and regulatory requirements governing IA, handles major tasks involved in developing an IA organization, defines IA requirements, integrates IA in the program's architecture, develops an acquisition IA strategy, collaborates with NSA in defining and implementing cryptography for data protection, conducts or monitors appropriate IA testing and validation, and plans for and oversees IA certification and accreditation for the program within DoD acquisition life cycle as defined by DoDI 5000.02.

IAE has the responsibility to develop an IA Strategy that the DoD CIO must certify for Major Automated Information System (MAIS) programs or confirm for Major Defense Acquisition Programs (MDAPs) before each Milestone approval. One of the key elements of this certification or confirmation is the DoD CIO's determination that the program has an IA strategy that is consistent with DoD policies, standards, and architectures. DoDI 8580.1 provides guidance on how to implement policy, assign responsibilities, and prescribe procedures necessary to integrate IA into the Defense Acquisition System.

IAE supports the program to meet its IA responsibility that includes Information Systems Security Engineering (ISSE), cryptography certification, C&A, usually through the DoD Information Assurance Certification and Accreditation Process (DIACAP) process IAW DoDI 8500.2, and helps develop program plans, budgets, and contracts, as appropriate to integrate IA into overall Systems Engineering. IAM also provides technical validation of IA requirements and selection of IA-enabled technology and products for space systems that facilitate GIG connection and net-centric operations.

Figure 24 provides the acquisition life cycle framework within which IAE performs as well as the products that the IAE develops or contributes to. This figure and documents in Table 23 provide details on compliance requirements to perform IA planning, support pre- and post-contract award acquisition activities, and perform IA management and engineering over the system lifecycle. SMC Program Offices appoint, establish, and implement IA program strategies and objectives consistent with the tenets of appropriate policies, SMC acquisition objectives, and program objectives. IAM contributions to the RFP include (i) IA portion of RFP Section H (Special Contract Requirements) that identifies IA policy and requirements for the design, acquisition, installation, operation, upgrade, or replacement of all DoD information systems IAW the appropriate documents listed in (ii) a section for PWS/SOO to communicate specific IA requirements, functions, and tasks required of the offerors, IA roles to be performed, specific IA controls to be satisfied, and any specific IA performance criteria (e.g., availability requirements); (iii) CDRL entries to incorporate any IA-related data products and documents that the potential contractor needs to produce; (iv) IA portion of RFP Section M, Evaluation Factors for Award, to list evaluation factors and significant subfactors by which the offers are evaluated and the relative importance that the government places on these evaluation factors and sub-factors. When IA performance is critical, the RFP may specifically address the impact of non-compliance

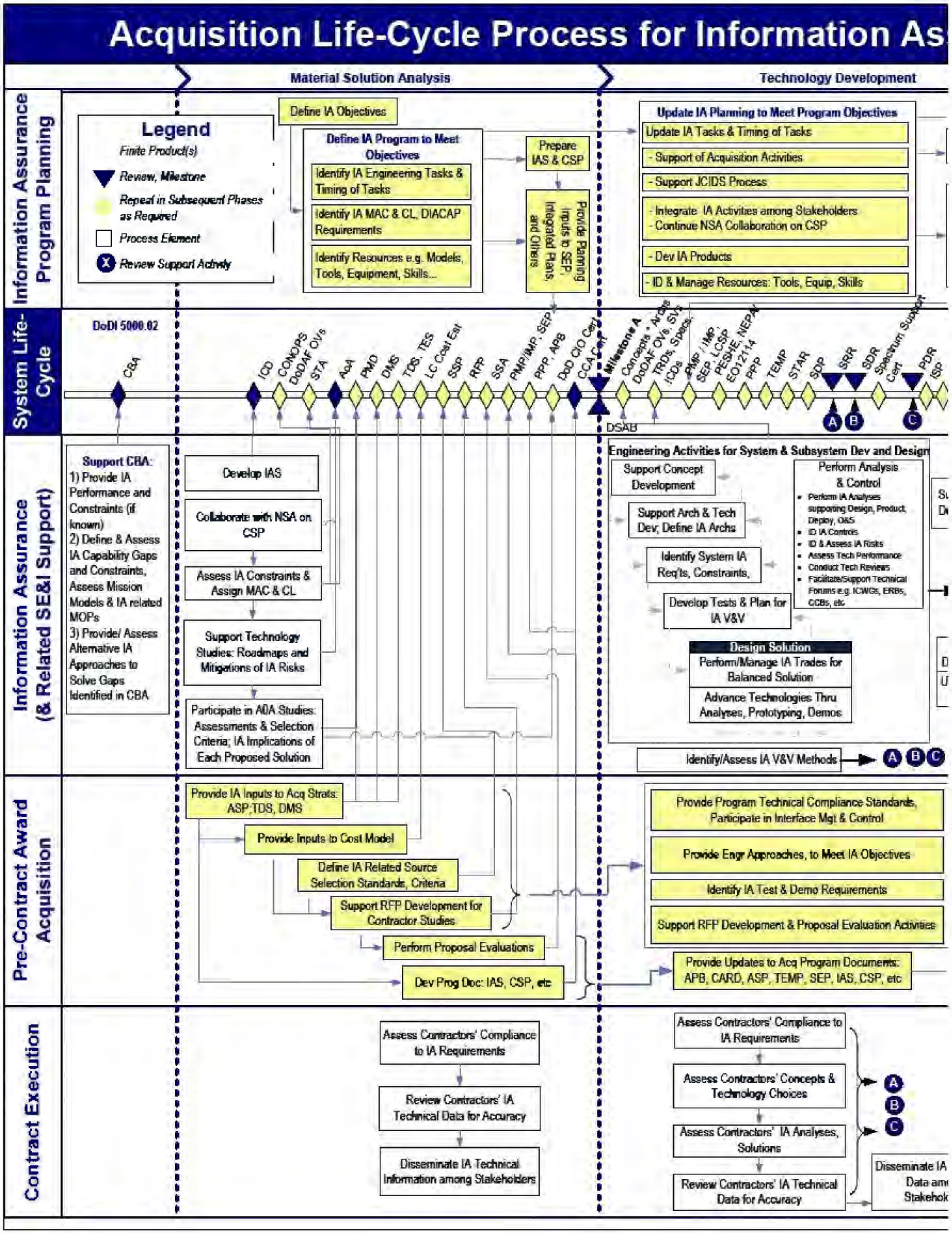
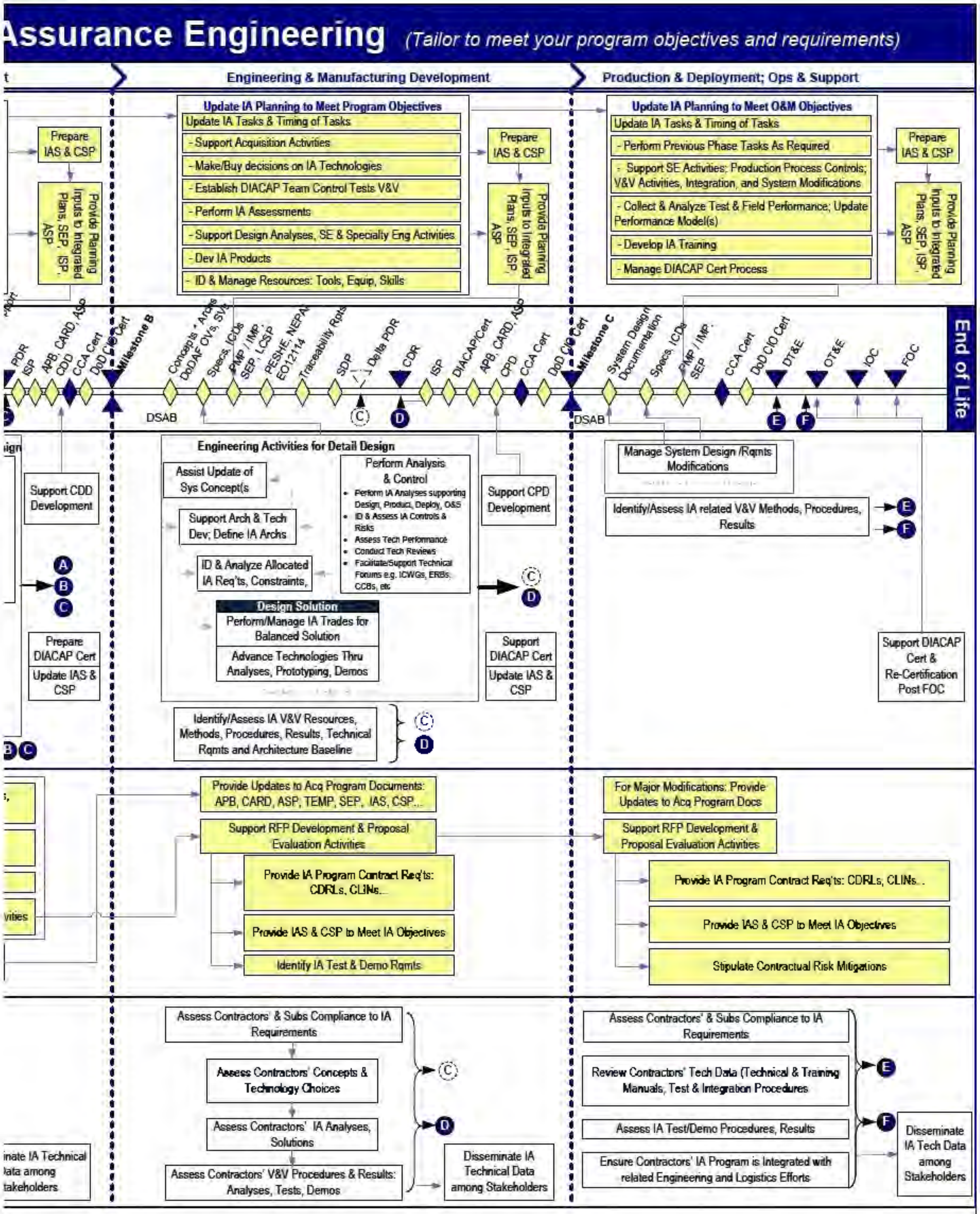


Figure 24 SMC Acquisition life cycle process for SMC Information Assurance Engineering


Assurance Engineering (Tailor to meet your program objectives and requirements)
Engineering & Manufacturing Development
Production & Deployment; Ops & Support
Update IA Planning to Meet Program Objectives
Update IA Tasks & Timing of Tasks
- Support Acquisition Activities
- Make/Buy decisions on IA Technologies
- Establish DIACAP Team Control Tests V&V
- Perform IA Assessments
- Support Design Analyses, SE & Specialty Eng Activities
- Dev IA Products
- ID & Manage Resources: Tools, Equip, Skills
Prepare IAS & CSP
Provide Planning Inputs to Integrated Plans, SEP, ISP, ASP
Update IA Planning to Meet O&M Objectives
Update IA Tasks & Timing of Tasks
- Perform Previous Phase Tasks As Required
- Support SE Activities; Production Process Controls; V&V Activities, Integration, and System Modifications
- Collect & Analyze Test & Field Performance; Update Performance Model(s)
- Develop IA Training
- Manage DIACAP Cert Process
End of Life
DSAB
Engineering Activities for Detail Design
Assist Update of Sys Concept(s
Support Arch & Tech Dev; Define IA Archs
ID & Analyze Allocated IA Req'ts, Constraints,
Perform Analysis & Control
Design Solution
Perform/Manage IA Trades for Balanced Solution
Advance Technologies Thru Analyses, Prototyping, Demos
Support CDD Development
Support CPD Development
Prepare DIACAP Cert
Update IAS & CSP
Support DIACAP Cert
Identify/Assess IA V&V Resources, Methods, Procedures, Results, Technical Rqmts and Architecture Baseline
Manage System Design /Rqmts Modifications
Identify/Assess IA related V&V Methods, Procedures, Results
Support DIACAP Cert & Re-Certification Post FOC
Provide Updates to Acq Program Documents: APB, CARD, ASP, TEMP, SEP, IAS, CSP...
Support RFP Development & Proposal Evaluation Activities
Provide IA Program Contract Req'ts: CDRLs, CLINs...
Provide IAS & CSP to Meet IA Objectives
Identify IA Test & Demo Rqmts
For Major Modifications: Provide Updates to Acq Program Docs
Stipulate Contractual Risk Mitigations
Assess Contractors' & Subs Compliance to IA Requirements
Assess Contractors' Concepts & Technology Choices
Assess Contractors' IA Analyses, Solutions
Assess Contractors' V&V Procedures & Results: Analyses, Tests, Demos
Disseminate IA Technical Data among Stakeholders
Review Contractors' Tech Data (Technical & Training Manuals, Test & Integration Procedures
Assess IA Test/Demo Procedures, Results
Ensure Contractors' IA Program is Integrated with related Engineering and Logistics Efforts
Disseminate IA Tech Data among Stakeholders

or lack of IA performance on the part of the contractor, and may set up a system of rewards and punishment based on contractor performance. The IAM supports the PM to identify IA test and evaluation requirements, metrics, success criteria, and how and when best to conduct the IA testing. And, if essential to the program, IAM helps develop CLINs to assure resources for critical IA technology for SE design implementation and integration .requirements); (iii) CDRL entries to incorporate any IA-related data products and documents that the potential contractor needs to produce; (iv) IA portion of RFP Section M, Evaluation Factors for Award, to list evaluation factors and significant subfactors by which the offers are evaluated and the relative importance that the government places on these evaluation factors and sub-factors. When IA performance is critical, the RFP may specifically address the impact of non-compliance or lack of IA performance on the part of the contractor, and may set up a system of rewards and punishment based on contractor performance. The IAM supports the PM to identify IA test and evaluation requirements, metrics, success criteria, and how and when best to conduct the IA testing. And, if essential to the program, IAM helps develop CLINs to assure resources for critical IA technology for SE design implementation and integration.

MSA Phase – SMC Acquisition Products
Acquisition IA Strategy (IAS), Cryptography Security Plan (CSP)
IA Section in ASP, SEP, TDS, and CARD

1. **Materiel Solution Analysis.** The SMC PM establishes an IA organization and appoints an IAM/IAE. The IAM and his team of IA engineers supports IA acquisition activities to include (i) identification of IA requirements, (ii) determination of program Mission Assurance Category (MAC) and Confidentiality Level (CL) IAW DoDI 8500.02 for approval (iii) identification of baseline IA controls consistent with their MAC and CL and other possible IA requirements beyond the baseline that may be imposed through the Capstone Requirements Document (CRD), ICD, (iv) draft of an IA strategy, a living standalone document, using an IA strategy template as provided in DAG, and (v) collaboration with NSA to develop a Cryptography Security Plan (CSP) that utilizes NSA-approved cryptography and implementation process. IAM supports registering of systems with the DoD Chief Information Officer (CIO) through the Component CIO, and guides the program for DoD CIO review and certification of the IA Strategy and the CSP at Milestone A. IAM also provides inputs to the overall Systems Engineering (SEP, TDS), cost estimates (CARD), solicitation/RFP development for Contractor studies, and proposal evaluation activities as necessary.

TD Phase – SMC Acquisition Products
Updates to Acquisition IAS, CSP
IA Section in ASP, SEP, and CARD
RFP: IA objectives in the SOO; IA related tasks in SOW, IA data products in CDRLs; SMC- IA standards - tailored
Inputs to Initial ISP
Initial DIACAP Package for DAA approval includes SIP, DIP, DIACAP Scorecard, POA&M, and supporting artifacts including IA Control validation procedures and tests and EIDTR/eMASS registration
STAR

2. **Technology Development.** If MS A phase for a program is skipped, the IAE completes all actions required before MS A. For MS B, IAM (i) ensures IA considerations are incorporated in the program ASP, (ii) updates and submits IA Strategy, (iii) secures resources for IA in the program budget to cover the cost of developing, procuring, testing, certifying and accrediting, and maintaining the posture of system IA solutions, (iv) conducts DoD Information Assurance Certification and Accreditation Process (DIACAP)or other applicable certification and accreditation (C&A) process, and (v) updates CSP IAW NSA guidelines and Information Systems Security Engineering (ISSE) support.

3. **Engineering & Manufacturing Development.** For MS C, the IAE (i) incorporates and implements IA design solutions based on necessary ISSE efforts, (ii) tests and evaluates IA solutions, (iii) supports C&A activities for the system under DIACAP to obtain necessary approvals from the Designated Accrediting Authority (DAA), (iv) provides inputs to and supports all program acquisition activities to include the development of updates to the IA strategy and CSP, updates to the cost estimate, and (v) supports solicitation/RFP development and proposal evaluation activities to ensure appropriate cost-effective IA technologies are acquired to meet program objectives.

EMD Phase – SMC Acquisition Products
Updates to Acquisition IAS, CSP, inputs to ISP
DIACAP Package for DAA approval includes SIP, DIP, DIACAP Scorecard, POA&M, and supporting artifacts including IA Control validation procedures and tests and EIDTR/eMASS registration
RFP: IA objectives in the SOO; IA related tasks in SOW, IA data products in CDRLs; SMC- IA standards - tailored
STAR

4. **Production & Deployment, Operations & Support.** The IAM maintains the system's security posture throughout its lifecycle. It includes (i) periodic DIACAP re-accreditation, (ii) assessment of IA during IOT&E on the mature system.

P&D / O&S Phase – SMC Acquisition Products
Updates to IAS, CSP, inputs to final ISP
RFP: IA objectives in the SOO; IA related tasks in SOW, IA data products in CDRLs; SMC- IA standards
Periodic DIACAP Package for DAA approval includes SIP, DIP, DIACAP Scorecard, POA&M, and supporting artifacts including IA Control validation procedures and tests and EIDTR/eMASS registration

IA Engineers' Contributions to the Engineering Life Cycle Framework

Relationship to SE Organization

The IAE plans and executes essential IA engineering and management efforts in an integrated and effective manner within the context and full support of the overarching Systems Engineering function. IAE ensures that each IA SED contribution is timely, adequate, consistent, and compliant. The IAE ensures that their contributions are channeled through the Systems Engineering *Analyses and Control* activity.

As depicted in the IAE contributes to the SE process with IA concept and architecture development and analyses, modeling and simulation efforts, make or buy (COTS/GOTS) solutions, and threat, risk, and technology studies. IAE ensures IA technical information is current and commensurate with program maturity and is appropriately applied through systematic control, collaboration, and sharing across the organization to integrate with all SE engineering functions through the system lifecycle. This includes application of mandated security standards, available from DISR online, as appropriate to the system security posture. IAM lays the groundwork for a successful C&A process by facilitating consensus among the PM, Component CIO, and DoD CIO on pivotal issues such as MAC, CL, and applicable Baseline IA Controls, selection of the appropriate C&A process, identification of the DAA, and documenting a timeline for the C&A process.

Relationship to other SEDs

IA SED's relationship to other SEDs is summarized in Figure1. As shown in Figure 1, IA engineering solutions for the program strongly depend on Net-Centric Engineering SED. It is IAE's responsibility to be cognizant of the computing and network environment and the data model for the program. Interoperable environments require robust and pervasive network level IA to assure Warfighter's data availability, integrity, and confidentiality.

IAE supports IA test and evaluation (T&E) as an integral part of the overall T&E process. DoD Instruction 5000.02 directs that IA test and evaluation be conducted during both Developmental Test and Evaluation and Operational Test and Evaluation. To ensure that IA testing adequately addresses system IA requirements, all sources of IA requirements must be considered. The primary source is the applicable set of baseline IA controls. Additional IA requirements may be imposed through capabilities documents, or as a result of the risk management process, or as directed by the DoD Components. An Interim Authorization to Operate or Authorization to Operate is required prior to conducting Operational Test, and should maintain Interim Authority to Test (IATT) and what that is used for. These authorizations are granted only after the bulk of C&A activities are concluded, and the DAA is satisfied with the residual risk to the system.

Tools Selection and Use

The IA Engineer considers effectiveness and efficiencies gained by selecting and using the best choice of information assurance tools considering the IA tool requirements, information sharing, automated data exchanges with other tools, and other considerations.

IA Functions Requiring Tools
Design and Architecture Modeling
Trade studies and analysis of IA technology, standards, and products
Requirements Analyses & Allocations
Security standards selection – DISRonline
IA registration tools e.g., EIDTR, eMASS
NSA-approved cryptography and implementation process selection
IA V&V, Development/Operational testing

Engineering Activities and Products over the Life Cycle

The following subsections delineate IA Engineer's contributions to engineering activities and technical products by DOD acquisition phase.

1. **Materiel Solution Analysis.** Specifically, during this phase the IA Engineer provides inputs to and supports: (i) system IA classification, (ii) the Capabilities Based Assessment process, (iii) threat assessment, (iv) risk assessment, (v) Net-Ready Key Performance Parameter (NR-KPP) and interoperability assessment, (vi) cryptography technology and implementation process assessment in collaboration with NSA, and if initiated (vii) the DIACAP assessment.

MSA Phase – Technical Products Required	
SMC IA Technical Products	**IA Contributions to Other Organizations' Products**
System Classification (MAC, CL)	IAS, ASP
Baseline and capability-based IA Controls	IAS, ASP, ICD, CDD, PWS/SOO
Threat assessment, ISSE, Information Operations Capstone Threat Capabilities Assessment	IAS, ASP,
Risk Assessment	IAS, ASP
Interoperability GIG-connectivity assessment	IAS
Cryptography Technology and implementation process (NSA support)	CSP, ASP, RFP
DIACAP assessment	IAS, ASP

2. **Technology Development.** During this phase the IA Engineer continues to provide inputs to and supports the JCIDS process. The IA Engineer also supports all the engineering activities to update IA products described in the MSA phase. IAE assists with developing architectural products like the DoDAF viewpoints (SV-4, SV-6) to incorporate IA design concepts.

   The IA Engineer develops and derives IA requirements and supports the SE requirements analyses and allocation process, participates in technology studies and technical solutions trades to ensure compliance with IA mandates, and security related standards selection to support certification and accreditation of the system. The IA Engineer also works closely with the SEs performing interface analyses, functional analyses, and the integration and verification and validation planning and execution. A more concerted effort is made to develop tests and IA solutions to validate required IA Controls. The IAE in this phase has an emphasis on IA technology and standards studies and trades to support SE function and overall inclusion of IA requirements in the system architecture.

TD Phase – Technical Products Required	
SMC IA Technical Products	**IA Contributions to Other Organizations' Products**
updated baseline and capability-based IA Controls	IAS, ASP, ICD, CDD, PWS/SOO
updated Cryptography Technology and implementation process (NSA support)	CSP, ASP, ISP, RFP
Technology and standards selection studies and trades	IAS, ASP, SEP, TDS
Interoperability and supportability studies and trades	IAS, SEP, ISP
updated Threat assessment (STAR, ISSE, Information Operations Capstone Threat Capabilities Assessment)	IAS, ASP, ISP
updated Risk Assessment	IAS, ASP, ISP
IA architecture, Interoperability GIG-connectivity assessment	IAS, ISP
update DIACAP assessment and supporting artifacts	IAS, ASP, DIACAP Package
Test and evaluate IA solutions	DIACAP Package

Furthermore, IAE also makes certain that the Net-Ready KPPs are achievable for net-centric operations and interoperability, including implementation of Internet Protocol version 6 (IPv6) as necessary. IAE ensures and supports activities for the program (capability, system, and/or service) to continuously provide survivable, interoperable, secure, and operationally effective information exchanges to enable a net-centric military capability while meeting IA requirements of availability, integrity, authentication, confidentiality, and non-repudiation over the entire lifecycle.

IAE also provides inputs to the IA section of the ASP that includes (i) applicable IA policy and guidance, (ii) IA technical considerations for choosing design characteristics and solutions, (iii) IA implementation schedule, (iv) cost, (v) funding profile, and (vi) staffing and support requirements.

3. **Engineering & Manufacturing Development.** IA Engineer continues to provide inputs to and supports the JCIDS process. The IAE (i) supports engineering activities to further develop or modify the IA component of the system architecture, (ii) ensures IA solution's compliance with the Global Information Grid (GIG) architecture, (iii) supports product selection and make/buy decision studies and trades, (iv) makes maximum use of enterprise IA capabilities and services, (v) supports procurement of IA/IA-enabled products with emphasis on leveraging COTS hardware and/or software and tools (DoD Instruction 5000.02, paragraph 6 of Enclosure 5), (v) helps Implement of security policies, plans, and procedures, (vi) continues to support technical solutions trades to ensure compliance with IA mandates, and security related standards selection to support certification and accreditation of the system. The IA Engineer also works closely with the SEs performing interface analyses, functional analyses, and the integration and verification and validation planning and execution, and (vii) conducts IA Training.

EMD Phase – Technical Products Required	
SMC IA Technical Products	**IA Contributions to Other Organizations' Products**
updated baseline and capability-based IA Controls	IAS, ASP, ICD, CDD, PWS/SOO
updated Cryptography Technology and implementation process (NSA support)	CSP, ASP, ISP, RFP
Product selection and make/buy decision studies and trades	IAS, ASP, SEP, ISP, TDS
updated Threat assessment (STAR, ISSE, Information Operations Capstone Threat Capabilities Assessment)	IAS, ASP, ISP
updated Risk Assessment	IAS, ASP, ISP, CSP
updated IA architecture, Interoperability GIG-connectivity assessment	IAS, ISP
update DIACAP assessment and supporting artifacts	IAS, ASP, DIACAP Package
Test and evaluate IA solutions and products	DIACAP Package
IA training products	OI, processes

4. **Production & Deployment, Operations & Support.** IA Engineer continues to provide inputs to and supports the JCIDS process.

P&D / O&S Phase – Technical Products Required	
SMC IA Technical Products	**IA Contributions to Other Organizations' Products**
Periodic re-accreditation	DIACAP Package
Assess IA posture	IOT&E report

IA Engineers' Contributions to Program and Project Management

Each SMC program defines their business model and approach based primarily on program objectives, technical challenges, organizational structure, and required engineering planning including IA for cost-effective execution.

IA Engineer supports the PM in meeting overall IA protection responsibility for the National Security Systems (NSS) system IAW the 8500 series of policy and guidance. It includes definition, development, design, maintenance, and operation of interoperable and GIG-connected systems in a net-centric environment with full IA protection.

SMC Program Management Products
IAS, ASP, RFP, PWS, SOO
Decision-making & problem solving inputs
Cost Estimate (CARDs)
DIACAP Package and artifacts, IA V&V procedures
Developmental and Operational tests
Threat Assessment and Risk Management Inputs

For acquisitions of Automated Information Systems (AIS), IAM coordinates with enclaves hosting applications to addresses operational security risks and identifies all system security needs using baseline IA controls as a common framework to facilitate this process. The burden for ensuring that an AIS application has adequate assurance is a shared responsibility of both the AIS application IAM and the DAA for the hosting enclave. However, the responsibility for initiation of this negotiation process lies clearly with the IAM. IAM, to the extent possible, draws on the common IA capabilities that can be provided by the hosting enclave.

Outsourced IT-based processes must comply with the IA requirements in the 8500 policy series. The vendor is responsible for delivering outsourced business processes supported by private sector information systems, outsourced information technologies, or outsourced information services that present specific and unique challenges for the protection of the GIG. The IAE for an Outsourced IT-based process carefully defines and assesses the functions to be performed and identifies the technical and procedural security requirements that must be satisfied to protect DoD information in the service provider's operating environment and interconnected DoD information systems. The IA Engineer contributes to the development of the identified program management products.

Execution of IA planning is typically defined through the IA Strategy document. The IA Engineer provides full support to define the program and technical objectives where IA challenges and risks are known or anticipated. The IA Engineer assists to establish the business model, develop program planning and schedules, and define and implement program processes. The IA Engineer ensures the IA components of the program are appropriately represented in the program plans, program schedules, work breakdown schedules, cost estimates. The IA Engineer also reports their technical performance and progress. The IA Engineer shares in the risk management responsibilities to identify, assess, and propose mitigating actions of IA related risks. They also support the program manager's problem identification, resolution, and decision-making processes.

Appendix S – Net-Centric Engineering

Network-centric operations and warfare (NCOW) seeks to translate information advantage into a competitive advantage through robust networking of well-informed geographically-dispersed forces. NCOW (and net-centric engineering) focuses on five key areas to realize a net-centric (NC) information sharing vision: (i) data and services, (ii) secured availability, (iii) computing infrastructure readiness, (iv) communications readiness, and (v) Network Operations (NetOps) agility. DoD envisions moving to trusted NCOW through the acquisition of services and systems that are secure, reliable, interoperable, and able to communicate across a universal information infrastructure based on Internet Protocol (IP) and related non-proprietary and vendor-neutral standards. This internetworking, combined with changes in technology, organization, processes, and people allows new and robust forms of organizational behavior.

All SMC programs classified as National Security Systems (NSS) are required to comply with CJCSI 6212.01E, Interoperability and Supportability (I&S) of Information Technology and National Security Systems, 18 December 2008. Net-centric Engineering or NCOW vision is a major and enabling part of the enterprise-wide I&S requirements and often are used synonymously. SMC considers this new SED of great importance for enhancing space systems performance and, as such, joined SPAWAR and other organizations to develop tools, requirements, and implementable guidance that is available through the Net-Centric Enterprise Solutions for Interoperability (NESI) websites – this information can be used by the Net-centric Engineer (NCE) as such or tailored to help develop various acquisition artifacts including net-centric data/services strategy, ASP, and ISP.

The NCE has the responsibility to stand-up and execute the NCOW program. This SED describes the necessary tasks and products, the policy from which they are derived, their relationship to the acquisition framework, and the engineering details one needs to consider in working towards effective assured information-sharing NCOW.

Applicable governance, standards, and guidance

Table 24 identifies the significant governance, standards, and guidance which generally require SMC compliance for Net Centric Engineering.

Table 24 Governance, standards, and guidance that shape the Net-Centric Engineering discipline

Document No	Governance Title	Issue
DoDD 5000.01	Defense Acquisition System, E1.1.9 (Information Assurance), E1.1.10 (Information Superiority), E1.1.11 (interoperability T&E), E1.1.13 (Interoperability), E1.1.16 (interoperability)	current as of 20 Nov 07
DoDI 5000.02	Operation of the Defense Acquisition System, Enclosures 5 and 6.	08 Dec 08
CJCSI 6212.01E	Interoperability and Supportability of Information Technology and National Security Systems	18 Dec 08
DoDD 4630.05	Interoperability and Supportability of Information Technology (IT) and National Security Systems (NSS)	05May 04
DoDI 4630.8	Procedures for Interoperability and Supportability of Information Technology (IT) and National Security Systems (NSS)	30 Jun 04
CJCSM 3170.01C	Operation of the Joint Capabilities Integration and Development System, 01 May 2007	
	DoD IT Standards Registry (DISR)	current at http://disronline.

		disa.mil.
DoDD 8000.01	Management of the DoD Information Enterprise	10Feb 09
DoDD 8320.02	Data Sharing in a Net-Centric Department of Defense," December 2, 2004	
	IPv6 Memos	09 Jun 03 and 29 Sep 03
Document No	**Standards Title**	**Issue**
	Applicable (Program Specific) government and industry standards listed in the DoD Information Technology Standards Registry (DISR)	Various
Document No	**Guidance Title**	**Issue**
	DoD Net-Centric Services Strategy	Mar 07
	DoD Net-Centric Data Strategy	09 May 03
	DoD NetOps Strategic Vision	Dec 08
	DoD Global Information Grid (GIG) Architecture	Aug 03
	DoD Architecture Framework (DoDAF)	Nov 08
	DoD 8320.2-G, "Guidance for Implementing Net-Centric Data Sharing,"	12 Apr 06
	DoD CIO Net-Centric Checklist	
	AFSPC NC Checklist	
	Net-Centric Enterprise Solutions for Interoperability (NESI)	current at http://nesipublic. spawar.navy.mil.
	NESI Open Source site	https://nesi.spawar. navy.mil/account/ request.php
Defense Acquisition Guidebook (DAG)	DAG, Chapter 7: Acquiring Information Technology, Including National Security Systems, Section 7.3 Interoperability and supportability and Section 7.4 Net-centric Information Sharing	Current at https://dag.dau.mil/
	Planning Guide/Roadmap Toward IPv6 Adoption within the US Government – CIO Council	May 09

NCE's Contributions to the Acquisition Life Cycle Framework

The Program Office NCE supports implementation of statutory and regulatory requirements governing NCOW that includes NSS system acquisitions that effectively implements the mandated I&S objectives and requirements. The NCE: (i) implements NR-KPPs in the program's architecture, requirements, and acquisitions, (ii) leads the development of an Information Support Plan (ISP) to document the Program's compliance with I&S and NC mandates, and (iii) supports program acquisition activities and products to ensure net centric engineering is fully integrated into the acquisition strategies, planning, RFPs, source selection, and post-contract execution functions and processes. An equally important part of the NCE responsibilities is to stand-up and manage the necessary Community or Communities of Interest (COI) to meet the intent of DoDD 8320.02 in sharing user data that is visible, accessible, and understandable in a trusted environment.

The NCE implements the NR-KPPs through assessment and determination of NR-KPP information needs, data and services strategy, information timeliness, Information Assurance (IA), and net-ready attributes required for both the technical exchange of information and the end-to-end operational effectiveness of that exchange. The NCE ensures that NR-KPPs are sufficiently defined to include verifiable performance measures and associated metrics needed to evaluate timely sharing of information for a given capability. The NCE uses the NR-KPP documented in Capability Development Document (CDD) and Capability Production Document (CPD) to analyze, identify, and describe IT (includes all NSS) interoperability needs in the ISP and in the test strategies in the Test and Evaluation Master Plan.

The NCE activities to achieve NR-KPP compliance include:

- Supports integrated architecture products, including the Joint Common Systems Function List required to assess information exchange and operationally effective use for a given capability;
- Implements DoD Net-centric Data and Services strategies, including data and services exposure criteria IAW 8320.02;
- Ensures compliance with applicable Global information Grid (GIG) Technical Direction to include (i) use of the mandated DoD IT Standards Registry (DISR), (ii) development of mandated (CJCSI 6212.01) DoDAF viewpoints to meet the Net Centric Engineering requirements;
- Verifies compliance with DoD IA requirements IAW 8500.02; and
- Ensures compliance with Supportability elements to include Spectrum Analysis, Selective Availability Anti-Spoofing Module, and the Joint Tactical Radio System.

The NCE along with the Program Office team of engineers supports acquisition activities to include: (i) identification of NCOW requirements, (ii) initiation of analyses and relevant data to develop the Information Support Plan (ISP) or Enhanced ISP (EISP) or Tailored ISP (TISP), (iii) identification of data that the program needs to or is required to share, based on ICD/CDD, (iv) identification of possible users across and beyond the DoD, (v) initiation and management of COIs as necessary to develop vocabularies and service descriptions and, (vi) augmentation of existing DoD Discovery Metadata Specification (DDMS) and Net-centric Enterprise Services (NCES) to enable NCOW operations, if new metadata or services are defined. NCE provides this data as inputs to the program acquisition activities and products that include ASP, TDS, DMS, cost estimates (CARD), solicitation/RFP development, and proposal evaluation activities as necessary.

The NCE is solely responsible for and leads the development of the ISP – a repository of IT that focuses information on net-readiness, I&S, NR-KPP compliance, and information sufficiency concerns. ISP ensures a means to identify and resolve potential implementation issues and risks that can potentially restrict the ability of a program to perform as required. The NCE validates the ISP based on analysis of the program's integrated architecture as developed in the mandated DoDAF viewpoints. This analysis identifies information need, net-centric and I&S issues, and assesses compliance with DoD CIO policy and goals. Guidance for the mandatory format and content of the ISP is provided in DoDI 4630.8, enclosure 4, and CJCSI 6212.01. The Joint Staff utilizes the ISP in the I&S Certification process; J2 utilizes the ISP for intelligence supportability (CJCS Instruction 3312.01).

NCE contributions to the RFP include: (i) portions of SOO, SOW/PWS, and attached or referenced technical requirements documents -- TRD or acquisition specification and any specific I&S performance, technology, and open-standards compliance requirements such as IPv6-capable, IPsec in Section C communicating specific I&S requirements, functions, and tasks required of the offerors, , (ii) I&S CDRLs in Section J to incorporate any I&S-related data products and documents that the potential contractor needs to produce, (iii) special contract requirements in Section H that identifies I&S policy and requirements for the design, acquisition, installation, operation, upgrade, or replacement of all DoD information systems IAW the appropriate documents listed in Table 24 (iv) section for PWS/SOO to (iii) section in CDRL. (iv) specify data rights in Section J, (v) I&S related proposal instructions in Section L to include reusability requirements requiring component-based SW, layered architecture, and SOA, (vi) I&S specific proposal evaluation factors for award in Section M, and (vii) any post-award considerations that are important to the program. When I&S

performance is critical, the RFP specifically addresses the impact of non-compliance or lack of I&S performance on the part of the contractor, and can set up a system of rewards and punishment based on contractor performance. The NCE supports the PM to identify I&S test and evaluation requirements, open-standards compliance metrics, success criteria, and how and when best to conduct the I&S testing. When essential to the program, NCE helps develop CLINs to assure resources for critical I&S technology for SE design implementation and integration. It is recommended that NCE draw on and tailor Net-Centric Enterprise Solutions for Interoperability (NESI) guidance as applicable, and possibly include Parts 3, 4, and 5 as reference or guidance documents in the RFP.

Figure 25 shows the NCE contributions and required products within the DoDI 5000.02 phased acquisition lifecycle framework. This figure delineates the Program Office NCE responsibilities and requirements to perform NCE planning, support pre- and post-contract award acquisition activities, and performs NCE management and engineering across the system lifecycle, consistent with the tenets of appropriate policies, SMC acquisition objectives, and overall program systems engineering objectives. The Program Office NCE helps develop, attain approval for, and implement the Information Support Plan (ISP) and related artifacts to comply with I&S requirements in accordance with current DoD policy.

MSA Phase – SMC Acquisition Products
I&S inputs (NCOW requirements, NC data/services strategy, Vocabularies/service descriptions) for ISP, CPD, TRD, ASP, SEP, TDS, and CARD
Architecture products (DoDAF Viewpoints) OVs, CVs
Draft ISP

1. **Materiel Solution Analysis.** During this phase, the NCE helps establish an NCOW organization for the Program Office to support acquisition activities that include (i) identification of NCOW requirements including NR-KPP compliance, (ii) identification of data that the program is required to share based on ICD/CDD, (iii) identification of possible users across and beyond DoD, (iv) organization and management of COIs as necessary to develop vocabularies and service descriptions to possibly augment existing DoD Discovery Metadata Specification (DDMS) and Net-centric Enterprise Services (NCES), (v) initiation of I&S analyses and generation of relevant data including DoDAF viewpoints as mandated and listed in CJCSI 6212.01, and (vi) initiation of cost estimates for implementing NC requirements for the ISP. The NCE generates technical analyses and data that are then used by the overall program SE organization to produce an integrated system design that is documented in SEP, TRD, TDS, CPD, and CARD. NCE also supports RFP development and proposal evaluation activities. While ISP is not required until MS B, the foregoing engineering analyses and data can be documented in an early draft (recommended).

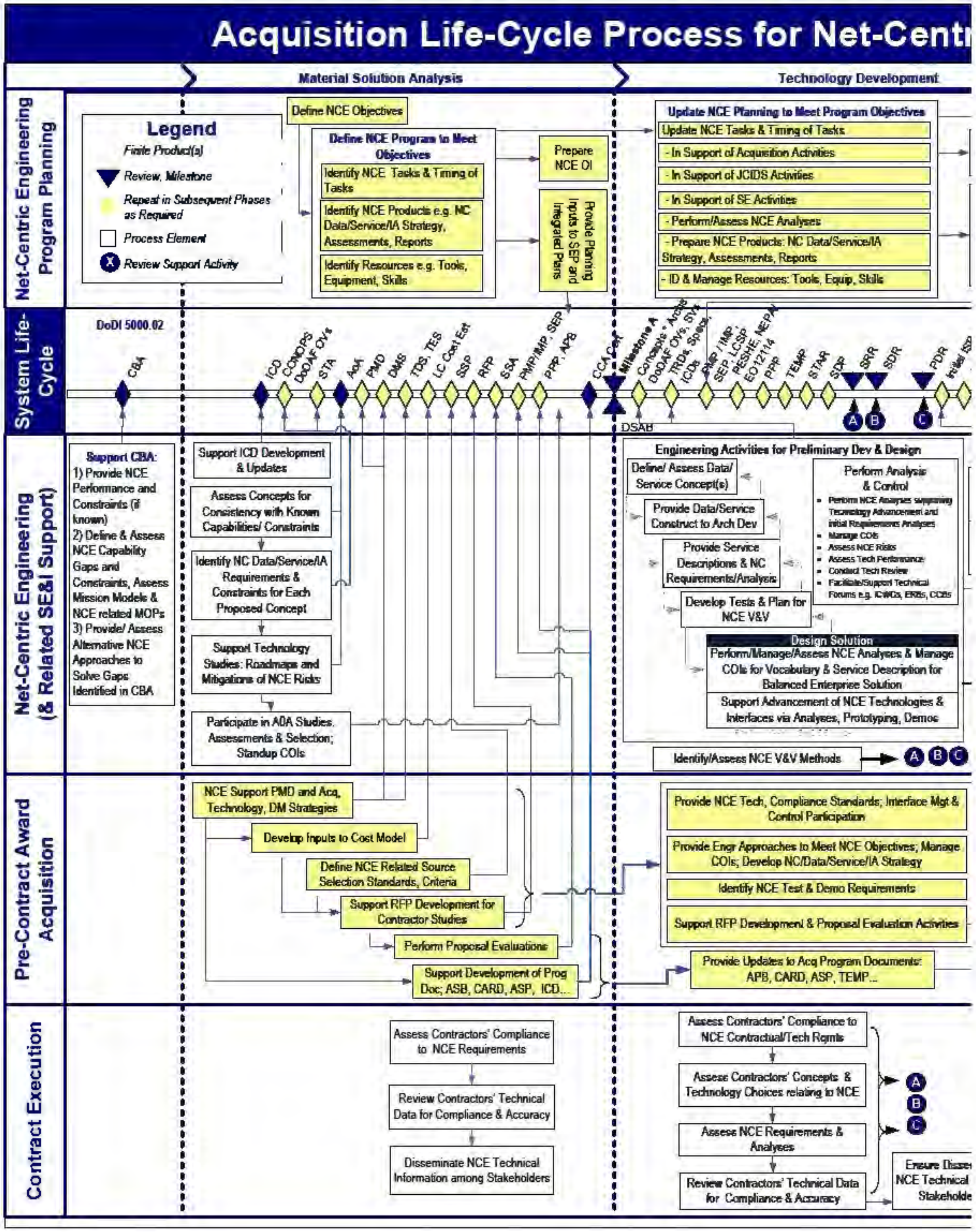
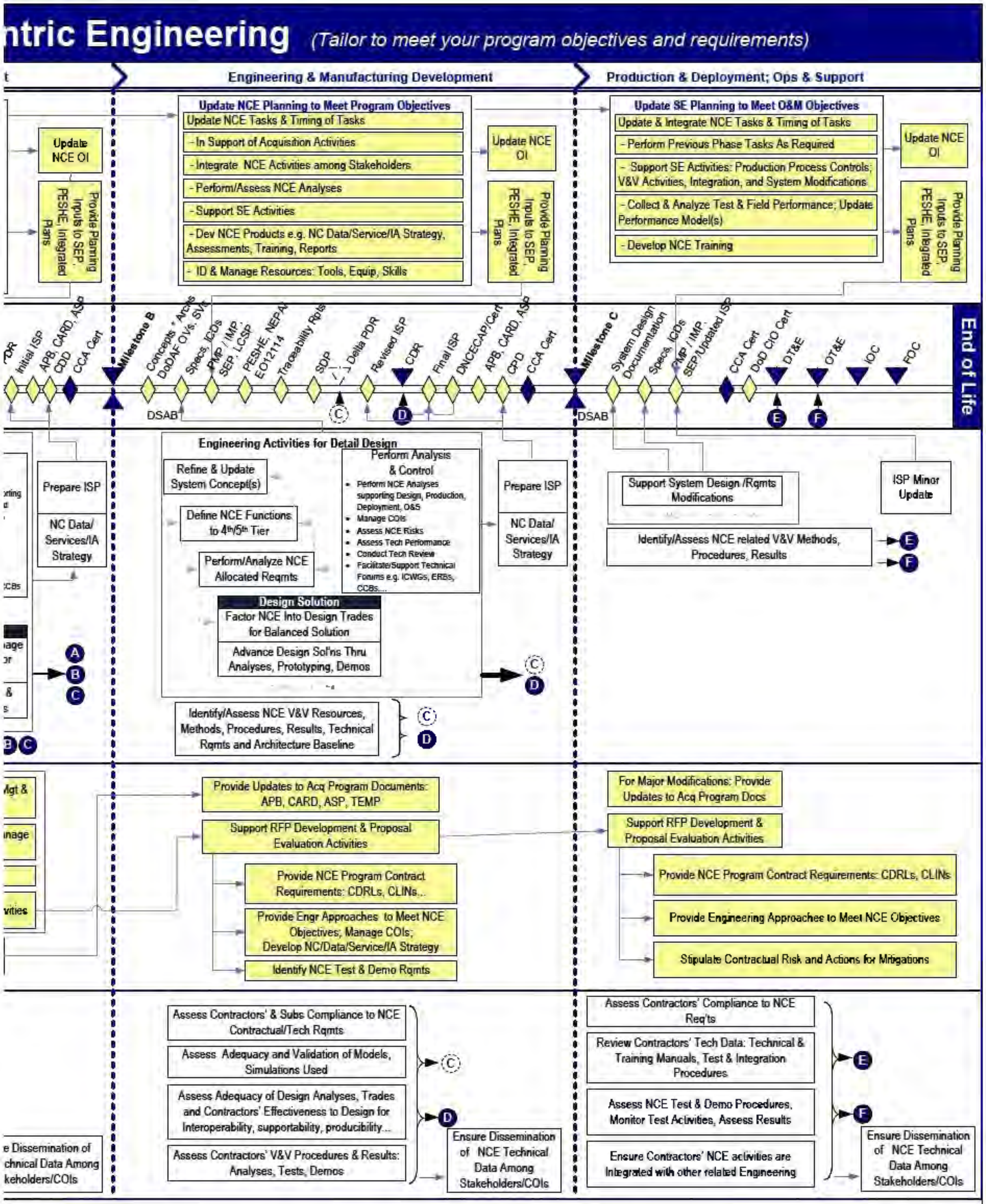


Figure 25 Acquisition life cycle process for SMC Net-Centric Engineering


ntric Engineering (Tailor to meet your program objectives and requirements)
Engineering & Manufacturing Development
Production & Deployment; Ops & Support
Update NCE OI
Provide Planning Inputs to SEP, PESHE, Integrated Plans
Update NCE Planning to Meet Program Objectives
Update NCE Tasks & Timing of Tasks
- In Support of Acquisition Activities
- Integrate NCE Activities among Stakeholders
- Perform/Assess NCE Analyses
- Support SE Activities
- Dev NCE Products e.g. NC Data/Service/IA Strategy, Assessments, Training, Reports
- ID & Manage Resources: Tools, Equip, Skills
Update NCE OI
Provide Planning Inputs to SEP, PESHE, Integrated Plans
Update SE Planning to Meet O&M Objectives
Update & Integrate NCE Tasks & Timing of Tasks
- Perform Previous Phase Tasks As Required
- Support SE Activities: Production Process Controls; V&V Activities, Integration, and System Modifications
- Collect & Analyze Test & Field Performance; Update Performance Model(s)
- Develop NCE Training
Update NCE OI
Provide Planning Inputs to SEP, PESHE, Integrated Plans
Initial ISP
APB, CARD, ASP
CDD
CCA Cert
Milestone B
Concepts + Archs
DoDAF OVs, SVs
Specs, ICDs
PMP / IMP
SEP, LCSP
PESHE, NEPA
EO12114
Traceability Rpts
SDP
Delta PDR
Revised ISP
CDR
Final ISP
DNCECAP/Cert
APB, CARD, ASP
CPD
CCA Cert
Milestone C
System Design Documentation
Specs, ICDs
PMP / IMP
SEP/Updated ISP
CCA Cert
DoD CIO Cert
DT&E
OT&E
IOC
FOC
End of Life
DSAB
DSAB
Prepare ISP
NC Data/ Services/IA Strategy
Engineering Activities for Detail Design
Refine & Update System Concept(s)
Define NCE Functions to 4th/5th Tier
Perform/Analyze NCE Allocated Reqmts
Perform Analysis & Control
Perform NCE Analyses supporting Design, Production, Deployment, O&S
Manage COIs
Assess NCE Risks
Assess Tech Performance
Conduct Tech Review
Facilitate/Support Technical Forums e.g. ICWGs, ERBs, CCBs...
Design Solution
Factor NCE Into Design Trades for Balanced Solution
Advance Design Sol'ns Thru Analyses, Prototyping, Demos
Prepare ISP
NC Data/ Services/IA Strategy
Identify/Assess NCE V&V Resources, Methods, Procedures, Results, Technical Rqmts and Architecture Baseline
Support System Design /Rqmts Modifications
ISP Minor Update
Identify/Assess NCE related V&V Methods, Procedures, Results
Provide Updates to Acq Program Documents: APB, CARD, ASP, TEMP
Support RFP Development & Proposal Evaluation Activities
Provide NCE Program Contract Requirements: CDRLs, CLINs...
Provide Engr Approaches to Meet NCE Objectives; Manage COIs; Develop NC/Data/Service/IA Strategy
Identify NCE Test & Demo Rqmts
For Major Modifications: Provide Updates to Acq Program Docs
Support RFP Development & Proposal Evaluation Activities
Provide NCE Program Contract Requirements: CDRLs, CLINs
Provide Engineering Approaches to Meet NCE Objectives
Stipulate Contractual Risk and Actions for Mitigations
Assess Contractors' & Subs Compliance to NCE Contractual/Tech Rqmts
Assess Adequacy and Validation of Models, Simulations Used
Assess Adequacy of Design Analyses, Trades and Contractors' Effectiveness to Design for Interoperability, supportability, producibility...
Assess Contractors' V&V Procedures & Results: Analyses, Tests, Demos
Ensure Dissemination of NCE Technical Data Among Stakeholders/COIs
Assess Contractors' Compliance to NCE Req'ts
Review Contractors' Tech Data: Technical & Training Manuals, Test & Integration Procedures
Assess NCE Test & Demo Procedures, Monitor Test Activities, Assess Results
Ensure Contractors' NCE activities are Integrated with other related Engineering
Ensure Dissemination of NCE Technical Data Among Stakeholders/COIs

2. **Technology Development.** NCE helps define all information needs and related-dependencies including data rights according to DoD Instruction 4630.8, CJCSI 6212.01, CJCSI 3170.01, and the JCIDS Manual to ensure I&S is addressed in the ISP and CDD. NCE updates required DoDAF products as listed in the CJCSI 6212.01 and NR-KPP compliance for the ISP and ASP. NCE updates NC data/services strategy using the COI as necessary. NCE submits the Initial ISP for formal coordinated review according to DoD Instruction 4630.8. NCE Tailors and incorporate SMC/NESI I&S and NCE requirements in SOO, SOW, and RFP as needed.

TD Phase – SMC Acquisition Products
Initial ISP
Update Architecture products (DoDAF Viewpoints)
I&S inputs (NCOW requirements, NC data/services strategy, Vocabularies/service descriptions) for ISP, CPD, TRD, ASP, SEP, TDS, and CARD
RFP: I&S and NCE objectives in the SOO; I&S, NCE, and related tasks in SOW, I&S and NCE data products in CDRLs; tailored SMC/NESI I&S and NCE requirements

3. **Engineering & Manufacturing Development.** Before CDR, NCE develops a revised ISP updating all information needs and related-dependencies according to DoDI 4630.8, CJCSI 6212.01, CJCSI 3170.01, and the JCIDS Manual to ensure information supportability is fully addressed. NCE updates DoDAF viewpoints, NR-KPP compliance, and tailored NCE requirements for ISP, SOO, SOW, and RFP as needed. NC data/services strategy is also updated using the COI as needed.

EMD Phase – SMC Acquisition Products
Revised ISP (before CDR), Final ISP (before MS C)
Revised Architecture products (DoDAF Viewpoints)
I&S inputs (NCOW requirements, NC data/services strategy, Vocabularies/service descriptions) for ISP, CPD, TRD, ASP, SEP, TDS, and CARD
RFP: I&S and NCE objectives in the SOO; I&S, NCE, and related tasks in SOW, I&S and NCE data products in CDRLs; tailored SMC/NESI I&S and NCE requirements

NCE produces the Final ISP before MS C in compliance with the mandates. The Final ISP is submitted for review and acceptance conducted by J2 and J6 to issue intelligence certifications and I&S certifications as required in CJCSI 3312.01 and 6212.01. NCE helps guide the ISP through DoD CIO approval and submission to JCPAT-E as the Final ISP of Record. The Final ISP of Record is required for Joint Interoperability Test Command's Interoperability Test Certification.

4. **Production & Deployment, Operations & Support.** After Final Build Approval for Space Programs (or after Milestone C), NCE Submits an updated ISP for minor upgrades that does not require a full review process. However, for each major upgrade (e.g., block or increment), NCE submits an updated ISP for formal, coordinated, Initial ISP Review according to DoD Instruction 4630.8.

P&D / O&S Phase – SMC Acquisition Products
Updated Final ISP when required
Updated Architecture products (DoDAF Viewpoints)
I&S inputs (NCOW requirements, NC data/services strategy, Vocabularies/service descriptions) for ISP, CPD, TRD, ASP, SEP, TDS, and CARD
RFP: I&S and NCE objectives in the SOO; I&S, NCE, and related tasks in SOW, I&S and NCE data products in CDRLs; tailored SMC/NESI I&S and NCE requirements

NCEs' Contributions to the Engineering Life Cycle Framework

Relationship to SE Organization

The NCE addresses NCOW from an enterprise architecture perspective. As part of the overall mission and system design, the NCE defines and applies a collection of policies, standards, methodologies, services, and mechanisms to maintain mission integrity with respect to people, process, technology, information, and supporting infrastructure. The objective is to ensure enterprise-wide data-centric discoverable information availability within a shared and protected environment. Given mission objectives and system design, NCE articulates and integrates a coherent structure of NC services and mechanisms, develops an NC Framework, NC operational processes, and as a part of the systems engineering function, assists integration of NCOW/NR-KPP compliance requirements into the system at the earliest time possible in the acquisition process. A well-executed NC "design for system/enterprise" leads to a visible, accessible, institutional, understandable, trusted, and best protected information system with known risks and shortfalls. The NCE ensures that their contributions are channeled through the Systems Engineering *Analyses and Control* activity (Figure 25).

As depicted in Figure 25 the NCE contributes to the SE process with Net Centric Engineering concept and architecture development and analyses, modeling and simulation efforts, make or buy (COTS/GOTS) solutions, cost estimates, and threat, risk, and technology studies. NCE ensures technical information is current and commensurate with program maturity and is appropriately applied through systematic control, collaboration, and sharing across the organization to integrate with all SE engineering functions through the system lifecycle. This includes application of mandated Net Centric Engineering and I&S standards, especially those available from DISRonline, as appropriate.

Tools available to NCE to implement NCOW/NR-KPP requirements include NESI, a cross-service effort with SMC participation that implements DoDI 4630.8 interoperability process. NESI provides actionable guidance to achieve NCOW I&S goals addressing architecture, design, and implementation. It offers compliance checklists, specific design and engineering knowledge, and recommendations to implement NC solutions. NCE tailors and implements NESI guidance commensurate with program maturity as necessary.

Community of Interest (COI) is an informal and loosely coupled organization construct that enables a "group of users that must exchange information in pursuit of its shared goals, interests, missions, or business processes and therefore must have shared vocabulary for the information exchanges" (DoD 8320.2). NCE lays the groundwork for a successful COI process, recruiting ad hoc members from formal organizations who may produce, develop, or consume program data as necessary. Within the COI collaborative environment, NCE (i) helps delineate between a program's public and private data sets and services, (ii) develops information sharing or service level agreements with other organizations, and (ii) helps make, disseminate, and maintain program vocabulary, ontology, and formal schemas for sharing and reuse.

Support required of NCE over the acquisition lifecycle of the system ensures that:

- system is Internet Protocol (IP) compliant, has IPv6-capability, employs vendor-neutral and non-proprietary standards, and offers highest possible quality of service;
- program developed information is shared with commensurate authentication, confidentiality, availability, and integrity;
- data and services strategy is consistent with timely discovery and availability, authoritative posting of data for reuse, and assured sharing.

Relationship to other SEDs

NCE SED's relationship to other SEDs is summarized in Figure 1.

Relationship with IA Engineering. The NCE's solutions for the program strongly depend on the IA SED for authorization and information confidentiality and integrity. It is NCE's responsibility to be cognizant of the computing and network environment, the DIACAP process and required IA controls, the cryptographic support plans, and the data model for the program. This information, as developed in the IA Strategy and CCA compliance documents, is summarized in the ISP. Interoperable environments require robust and pervasive wire-level IA to assure Warfighter's data availability, integrity, and confidentiality. NCE supports the IAE to ensure technical validation of IA requirements through the DIACAP process IAW DoDI 8500.2, supports cryptography certification, and supports selection of IA-enabled technology and products for space systems that facilitate GIG connection and net-centric operations.

Relationship with Software Engineering. To accommodate an internetworking environment, software design must evolve from traditional platform-centric to the NC construction. Data- and service-oriented NC architecture require SW design that can no longer be conducted in a sandbox, but must reach out to open and vendor-neutral internetworking standards and protocols. NCE assists the SW engineer in analyzing the design and in the implementation of a data-centric solution that leads to a net-centric battlefield.

Relationship with Architecture Engineering. DoD enterprise to make critical information widely available requires close coordination of its constituent systems and organizations. This is possible only when component architectures across all programs are designed with data- and service-orientation to create a seamless information-sharing construct. In this respect, NCE assists architectural engineer in developing various DoDAF artifacts that facilitate internetworking, but especially the operational, system, and service viewpoints. NCE, in collaboration with the COIs, also helps with the development of the architectural vocabulary and schema like the AV-2 to ensure data is discoverable and understandable.

Relationship with T&E. NCE supports Net Centric Engineering test and evaluation (T&E) as an integral part of the overall T&E process as mandated for both Developmental Test and Evaluation and Operational Test and Evaluation. NCE ensures that testing adequately addresses system NR-KPP compliance and that the necessary verification and validation requirements are incorporated in the Master T&E plan. NCE also supports the Program Office to help develop program plans, budgets, and contracts, as appropriate to integrate NCOW into overall Systems Engineering.

Tools Selection & Use

The NCE considers effectiveness and efficiencies gained by selecting and using the best choice of NCE tools that are conducive to information sharing, automated data exchanges with other tools, and other considerations.

Typical NCE Functions Requiring Tools
Design and Architecture Modeling
Make or Buy decision, COTS product selection
Trades and analyses of NCE technology, standards, and products
Requirements Analyses & Allocations
NCE standards selection – DISRonline
DoD CIO NCOW Checklists
NESI tools and guidance
NCE government and industry V&V, Development/ Operational testing

Engineering Activities and Products over the Life Cycle

The following subsections delineate NCE's contributions to engineering activities and technical products by DOD acquisition phase.

1. **Materiel Solution Analysis.** Specifically, during this phase the NCE provides inputs to and supports (i) the Capabilities Based Assessment process, (ii) inclusion of NCOW requirements in system and operational concepts, (iii) development of data model, vocabularies and schema with COI participation as necessary, (iv) NR-KPP and I&S assessment, (v) identification of mandated and applicable open standards, and (vi) IA and cryptography technology consistent with DIACAP assessment in a net-centric environment.

MSA Phase – Technical Products Required	
SMC NCE Technical Products	**NCE Contributions to Other Organizations' Products**
Draft ISP	CPD, TRD, IAS, ASP
COI products	Vocabulary, data products, service definitions
I&S/NC Risk Assessment	IAS, ASP
Interoperability GIG-connectivity assessment	Data model, service descriptions, tailored DISR standards
NR-KPP assessment	IAS, ASP
DoDAF Viewpoints	TRD, SEP

2. **Technology Development.** During this phase the NCE continues to provide inputs to and supports the JCIDS process. The NCE also supports all the engineering activities to update NCE products described in the MS A phase. NCE assists development of required DoDAF viewpoints as listed in the CJCSI 6212.01.

   The NCE develops and derives NCE requirements and supports the SE requirements analyses and allocation process, participates in technology studies and technical solutions trades to ensure compliance with NR-KPP mandates, and NC as well as security related standards selection in support of NCOW. The NCE also works closely with the SEs performing interface analyses, functional analyses, and the integration and verification and validation planning and execution. A more concerted effort is made to develop tests and net centric engineering solutions to validate the required NR-KPPs. The NCE in this phase has an emphasis on NC technology and standards studies and trades to support SE function and overall inclusion of NCE requirements in the system architecture. Furthermore, NCE also makes certain that the NR-KPP is achievable for NCOW operations and interoperability, including implementation of IPv6-capability as necessary. NCE ensures and supports activities for the program (capability, system, and/or service) to continuously provide survivable, interoperable, secure, and operationally effective information exchanges to enable a net-centric military capability while meeting IA requirements of availability, integrity, authentication, accountability, confidentiality, and non-repudiation over the entire lifecycle.

TD Phase – Technical Products Required	
SMC NCE Technical Products	**NCE Contributions to Other Organizations' Products**
Initial ISP	CPD, TRD, IAS
Updated COI products	Vocabulary, data products, service definitions
Technology and standards selection studies and trades	IAS, TRD, ASP, SEP, TDS
Interoperability and supportability studies and trades	IAS, SEP, TRD, CPD
Updated Risk Assessment	IAS, ASP
Interoperability GIG-connectivity assessment	Data model, service descriptions, tailored DISR standards
NR-KPP assessment	IAS, ASP
DoDAF Viewpoints	TRD, SEP
Test and evaluate NCE solutions	TRD, Design Architecture
NCE cost analysis	ASP, CARD

NCE also provides inputs to the net centric engineering section in the ASP that includes: (i) applicable NCOW policy and guidance, (ii) technical considerations for choosing design characteristics and solutions, (iii) implementation schedule, (iv) cost, (v) funding profile, and (vi) staffing and support requirements.

3. **Engineering & Manufacturing Development.** The NCE continues to provide inputs to and supports the JCIDS process. The NCE: (i) supports engineering activities to further develop or modify the NC component of the system architecture, (ii) ensures NCE solutions are compatible with IP and related vendor-neutral open standards and comply with the GIG architecture, (iii) assists in product selection and make/buy decision studies and trades, (iv) makes maximum use of NCES capabilities, (v) supports procurement of NC-enabled and IPv6-capable products with emphasis on leveraging COTS HW/SW and tools (DoD Instruction 5000.02, paragraph 6 of Enclosure 5), (vi) helps Implement NCOW policies, plans, and procedures, (vii) continues to support technical solutions trades to ensure compliance with NR-KPP mandates to include security related standards selection to support certification and accreditation of the system, (viii) organizes and manages COIs to solicit feedback, develop vocabularies, and define services as necessary, and (ix) conducts NCOW training. The NCE also works closely with the SEs performing interface analyses, functional analyses, and the integration and verification and validation planning and execution.

EMD Phase – Technical Products Required	
SMC NCE Technical Products	**NCE Contributions to Other Organizations' Products**
Revised/final ISP	CPD, TRD, IAS
Updated COI products	Vocabulary, data products, service definitions
Technology and standards selection studies and trades	IAS, TRD, ASP, SEP, TDS
Interoperability and supportability studies and trades	IAS, SEP, TRD, CPD
Updated Risk Assessment	IAS, ASP
Interoperability GIG-connectivity assessment	Data model, service descriptions, tailored DISR standards
NR-KPP assessment	IAS, ASP
DoDAF Viewpoints	TRD, SEP
Test and evaluate NCE solutions	TRD, Design Architecture

4. **Production & Deployment, Operations & Support.** NCE submits an updated ISP for minor upgrades that does not require a full review process. For each major upgrade (e.g., block or increment), NCE submits an Updated ISP for formal, coordinated, initial ISP Review according to DoD Instruction 4630.8. NCE also helps maintain data model products and services for the operational phase of the program.

P&D / O&S Phase – Technical Products Required	
SMC NCE Technical Products	**NCE Contributions to Other Organizations' Products**
updated/initial ISP for increments	increment CPD, TRD
maintenance of data model and products, services	operational documents

NCE's Contributions to Program and Project Management

Each SMC program defines its business model and approach based primarily on program objectives, technical challenges, organizational structure, and required engineering planning including NCE for cost-effective execution.

SMC Program Management Products
IAS, ASP, RFP, PWS, SOO, TRD
Decision-making & problem solving inputs
Cost Estimate (CARDs)
Developmental and Operational tests
Threat Assessment and Risk Management Inputs

NCE supports the PM in meeting overall NCOW environment responsibility for the NSS system IAW applicable policy and guidance. It includes definition, development, design, maintenance, and operation of interoperable and GIG-connected system in a net-centric environment with full IA protection. NCE also identifies, arranges for, and integrates outsourced IT-based processes and services to meet unique challenges for the protection of the GIG.

The NCE develops and implements the NCE program planning to achieve NCOW/NR-KPP objectives and requirements. The planning defines the NCE tasks and functions to be performed; products to be developed; timing of tasks, task outputs, resources (skills, tools, equipment, and completion criteria). The NCE plans tasks to integrate NCE activities within the program office, between contractors and COI stakeholders. The NCE plans the tasks to establish and manage information support plan and documents it in the ISP. The NCE interacts with other specialty engineers and the program organization to ensure internetworking mandates and objectives are met in the SW, Architecture Engineering, T&E, and the overall SE.

Execution of the NCE planning is typically defined through an OI. The NCE provides full support to define the program and technical objectives to help counteract implementation challenges and risks. The NCE ensures the NCE development and management components of the program are appropriately represented in the program plans, program schedules, work breakdown schedules, and cost estimates. The NCE reports on technical performance and progress to the program, shares in the risk management responsibilities, and supports the program manager's problem identification, resolution, and decision making processes.

Appendix T – Environmental Engineering

Environmental engineering is a well-defined and established SMC discipline. Instructions, guidance, and senior expert SMC Staff resources are available to assist the Program Office Environmental Engineer stand-up and execute the essential environmental engineering activities for the Program Office. Much of the Environmental Engineers' activities include implementation of the Environmental, Safety, and Operational Health (ESOH) mandates and best practices. In fact, ESOH is accomplished by a team of Environmental Engineers, Systems Engineers, System Safety Engineers, Reliability Engineers, Design Engineers, and others that understand their responsibilities to collaborate to achieve the ESOH objectives and requirements. The full intent is to identify potential environmental, safety, and operational health problems as early as possible in the product lifecycle to provide greater opportunities to eliminate hazards. As design decisions are made and the development efforts transition to production and fielding, ESOH related design improvements may be orders of magnitude more expensive.

The Environmental Engineer plans and executes the essential environmental engineering and management efforts in an integrated and effective manner to ensure that each environmental SED contribution is timely, adequate, consistent, and compliant. The Environmental Engineer POC ensures that their engineering contributions are channeled through the Systems Engineering *Analyses and Control* activity.

Environmental Engineering objectives include:

1. Establish environmental, safety, and operational health requirements based on public law, Government policy and mandates, operational constraints, and SMC practices.
2. Propose technical solutions and evaluate the inherent ESOH implications of proposed technical solutions to influence technical decisions to meet the environmental, safety, and operational health requirements.

Applicable governance, standards, and guidance

Policy, directives, and instructions that mandate SMC environmental engineering related program requirements are included in a wide range of mandates including those providing requirements for acquisition, Systems Engineering, T&E, Human Systems Integration (HSI), and others.
The DoDI 5000.02 Environmental / ESOH related mandates for SMC acquisition programs include:

1. Implementation of statutory requirement applicable to MDAPs and MAIS Acquisition Programs for PESHE (Including National Environmental Policy Act (NEPA) / (Executive Order) E.O. 12114 Compliance Schedule) Sections 4321-4347 of title 42, U.S.C. required at MS B, MS C, Full-Rate Production DR, (or Full Deployment DR)
2. Human-factors engineering to design systems that require minimal manpower; provide effective training; can be operated and maintained by users; and are suitable (habitable and safe with minimal environmental and occupational health hazards) and survivable (for both the crew and equipment).
3. The Program Manager (PM), Lead Systems Engineer / Chief Engineer, Environmental Engineer and System Safety Engineer ensure that appropriate HSI and Environment, Safety, and Occupational Health (ESOH) efforts are integrated across disciplines and into Systems Engineering to determine system design characteristics that can minimize the risks of acute or chronic illness, disability, or

death or injury to operators and maintainers; and enhance job performance and productivity of the personnel who operate, maintain, or support the system.

4. The Environmental Engineer and System Safety Engineer ensure integration of ESOH risk management into the overall Systems Engineering process for all developmental and sustaining engineering activities. As part of risk reduction, the Environmental Engineer and System Safety Engineer supports the PM to eliminate ESOH hazards where possible, and manage ESOH risks where hazards cannot be eliminated. The Environmental Engineer and System Safety Engineer ensures the acquisition program reviews and fielding decisions address the status of all high and serious risks, and applicable ESOH technology requirements. Prior to exposing people, equipment, or the environment to known system-related ESOH hazards, the Environmental Engineer and System Safety Engineer assists the PM to document that the associated risks have been accepted by the following acceptance authorities: the CAE for high risks, PEO-level for serious risks, and the PM for medium and low risks. The user representative shall be part of this process throughout the life cycle and shall provide formal concurrence prior to all serious- and high-risk acceptance decisions.

The SMC Systems Engineering Standard SMC-S-001 also provides requirements for the Environmental Engineer when chartered to perform the standard Environmental, Safety and Occupational Health (ESOH):

1. Provide ESOH requirements (system and allocated) , baselined and traceable to the system level
2. Identify hazards, analyze hazards including handling and disposal, propose and evaluate mitigation decisions
3. Ensure compliance to National Environmental Policy Act (NEPA) and Programmatic Environmental, Safety and Health Evaluation (PESHE) requirements
4. Define ESOH risks and corrective actions and alternatives to eliminate or reduce environmental, health, and identified hazards and unsafe conditions; Identify the threat of regulatory violations.
5. Establish criteria for monitoring and reporting of pollution elimination/reduction efforts.
6. Develop containment program, including procedures for safe use and disposal.
7. Include handling and disposal of hazardous material in life-cycle cost estimates.

Table 25 below identifies the significant governance, standards, and guidance which generally require SMC compliance for Environmental Engineering.

Table 25 Governance, standards, and guidance that shape the Environmental Engineering discipline

Document No	Governance Title	Issue
	NEPA, National Environmental Policy Act	
DoDI 5000.02	Operation of the Defense Acquisition System	08 Dec 08
DoDI 6055.1	DoD Safety and Occupational Health (SOH) Program	19 Aug 08
DoDI 6050.05	DoD Hazard Communication Program	15 Aug 06
DoDI 6055.07	Mishap Investigation, Reporting and Recordkeeping	03 Oct 00
DoDD 6055.9E	Explosives Safety Management and the DoD Explosives Safety Board	19 Aug 05
CJCSM 3170.01	Operation of the Joint Capabilities Integration and Development System	24 Jun 03
AFPD 63-12	Assurance of Operational Safety, Suitability, and Effectiveness	01 Feb 00
AFI 91-301	Air Force Occupational and Environmental Safety, Fire Prevention, and Health (AFOSH) Program	01 Jun 96
AFI 63-1201	Life Cycle Systems Engineering	23 Jul 07
SMCI 63-1205	Space Systems Safety Policy, Process, and Techniques	20 Aug 07
Title 42	US Code 4321-4347 National Environmental Policy Act (NEPA)	

AFPD 90-8	Environment, Safety, & Occupational Health (ESOH)	01 Sep 04
AFI 32-7061	Environmental Impact Analysis Process (EIAP)	12 Mar 03
AFI 32-7080	Pollution Prevention	12 May 94
AFI 32-7086	Hazardous Materials (HAZMAT) Management	01 Nov 04
Document No	**Standards Title**	**Issue**
SMC-S-015	End-of-Life Disposal of Satellites in Geosynchronous Altitude	19 Mar 10
NAS 411	Hazardous Materials Management Program	19 Jan 95
AFSPCMAN 91-710	Range Safety User Requirements Manual	01 Jul 04
AFSPCMAN 91-711	Launch Safety requirements for AF Space Command Organizations	
Document No	**Guidance Title**	**Issue**
	Air Force System Safety Handbook	Jul 00
AFJMAN 24-204	Preparing Hazardous Materials for Military Air Shipments	
	AFISC's Introduction to System Safety for Managers	
AFSCP 127-1	System Safety Program Management	
ASDP 127-1	System Safety Management	
	SMC Programmatic Environmental, Safety, And Health Evaluation (PESHE) Guide	25 Feb 02

The list of Data Item Descriptions (DIDs) provided below correlate with the tasks of Mil-Std-882C deliverables. SMCI 63-1205 provides the associations of these and additional DIDs with 882C as well as recommended tailoring. Data Item Description DI-HFAC-80746B describes equipment which interfaces with operators. The human engineering design emphasis expands to environmental factors including operator life support systems, protective clothing and equipment, noise, vibration, radiation, temperature ambient illumination, climatic effects, and other relevant environmental parameters.

Date Item Title	Date Item Description (DID)
Hazardous Materials Management Program Plan	DI-MGMT-81398
Hazardous Materials Management Program (HMMP) Report	DI-MISC-81397A
Explosive Ordnance Disposal Data	DI-SAFT-80931B
Human Engineering Design Approach Document-Operator	DI-HFAC-80746B
System Safety Hazard Report	DI-SAFT-80101A
Health Hazard Assessment Report	DI-SAFT-80106A
Mishap Risk Assessment Report	DI-SAFT-80109A

Environmental Engineers' Contributions to Acquisition Life Cycle Framework

The DoD acquisition life cycle is defined by DoDI 5000.02. Environmental engineering contributions over this life cycle are best represented within the phase of acquisition. Figure 26 provides the acquisition life cycle framework within which Environmental Engineers perform as well as the products that the Environmental Engineers develop or contribute to their development. This figure provide the requirements to perform environmental engineering planning, support pre and post contract award acquisition activities, and perform environmental engineering and management across the system lifecycle. SMC Program Offices establish and implement environmental engineering program strategies and objectives consistent with the tenets of appropriate policies, SMC acquisition objectives, and program objectives. The Program Office develops, attains approval for, and implements environmental engineering planning into the Systems Engineering Plan

(SEP) and higher level integrated planning (e.g., IMP) in accordance with current DoD policy. This planning is firmly based on program and technical objectives, strategies, DoD mandates, and instructions.

An effective environmental engineering program supports all of the major acquisition activities through the full system life cycle. The Environmental Engineer sufficiently defines the environmental engineering program planning to achieve the environmental engineering and overall program objectives and requirements. The planning specifies tasks and functions to be performed, timing of tasks, resources required, and products to be developed. This planning then forms the basis for the development of the program environmental engineering or ESOH Instruction (OI) and the PESHE. The environmental engineering planning and OI are then reflected appropriately in the WBS, IMS, PESHE, and other program documents that address environmental engineering related elements. The Environmental Engineer delineates the strategy for integrating ESOH into the systems engineering process and describes the ESOH management approach in the PESHE. The environmental engineering planning is executed concurrently with the Program Office Operating Instruction that documents the process to perform, control, and integrate all environmental engineering and management activities for each phase of acquisition.

The SMC Program Office environmental engineering planning (usually contained in the SEP and the detailed environmental engineering program planning) and OI are also based upon the appropriate program-approved life cycle. The following subsections delineate environmental engineering contributions to acquisition activities and products by DOD acquisition Phase.

MSA Phase – SMC Acquisition Products
PMD
ASP, TDS, DMS, TES
LC Cost Estimate
RFP inputs (environmental / ESOH requirements; ESOH assessment requirements; High level ESOH assessments of concepts
APB, CCA
Preliminary / draft Hazardous Material Management Strategy
SEP, LCMP

1. **Materiel Solution Analysis.** During this phase the Environmental Engineer provides inputs to and supports most program acquisition activities to include the development of the acquisition strategy, inputs to the cost estimates, solicitation/RFP development for Contractor studies, and proposal evaluation activities. The Environmental Engineer prepares an initial Hazardous Material Management Strategy and supports the System Safety Engineer to prepare the draft Systems Safety Management Plan (SSMP) / Systems Safety Program Plan (SSPP). The Environmental Engineer also contributes to the development of the MSA Phase acquisition products.

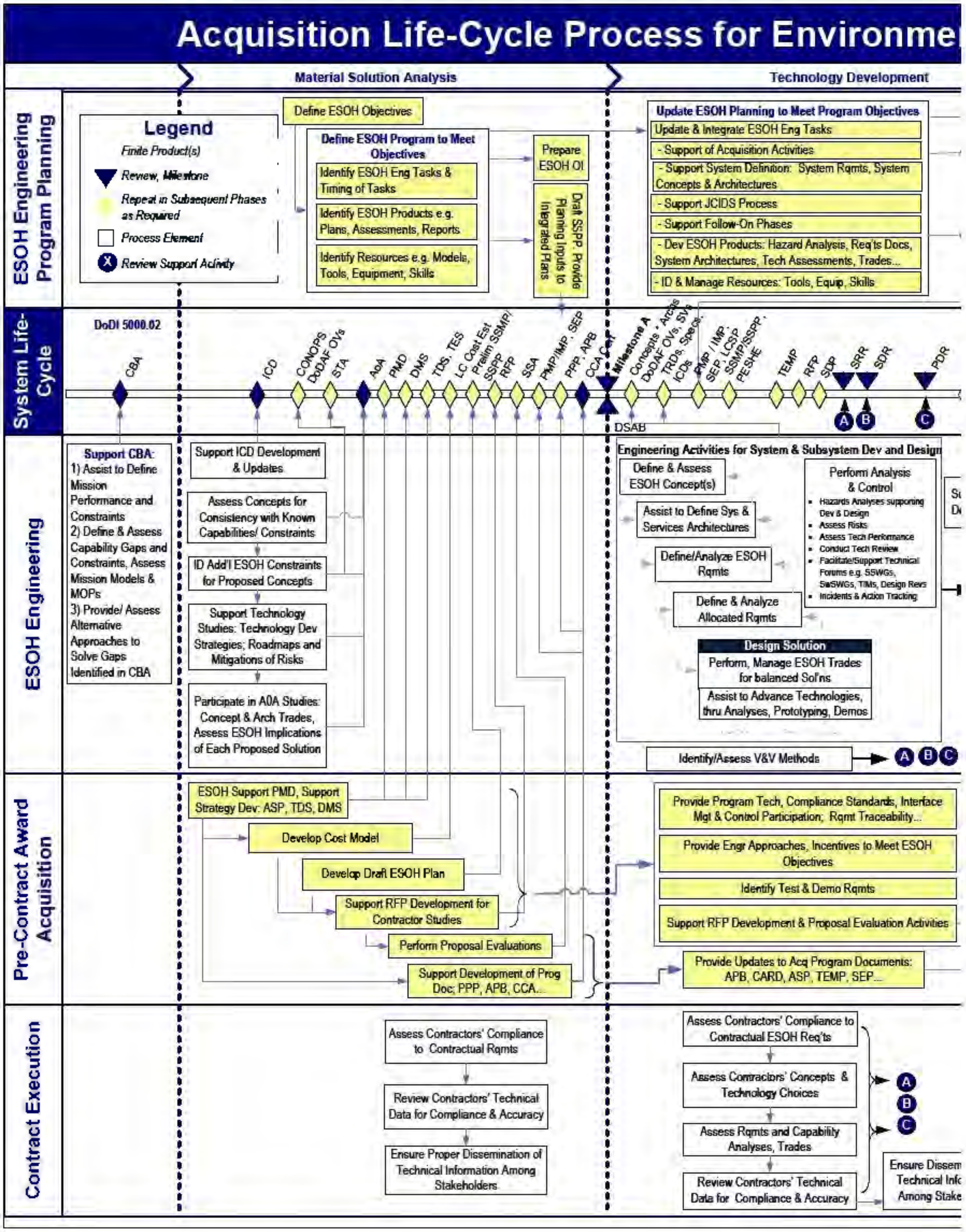
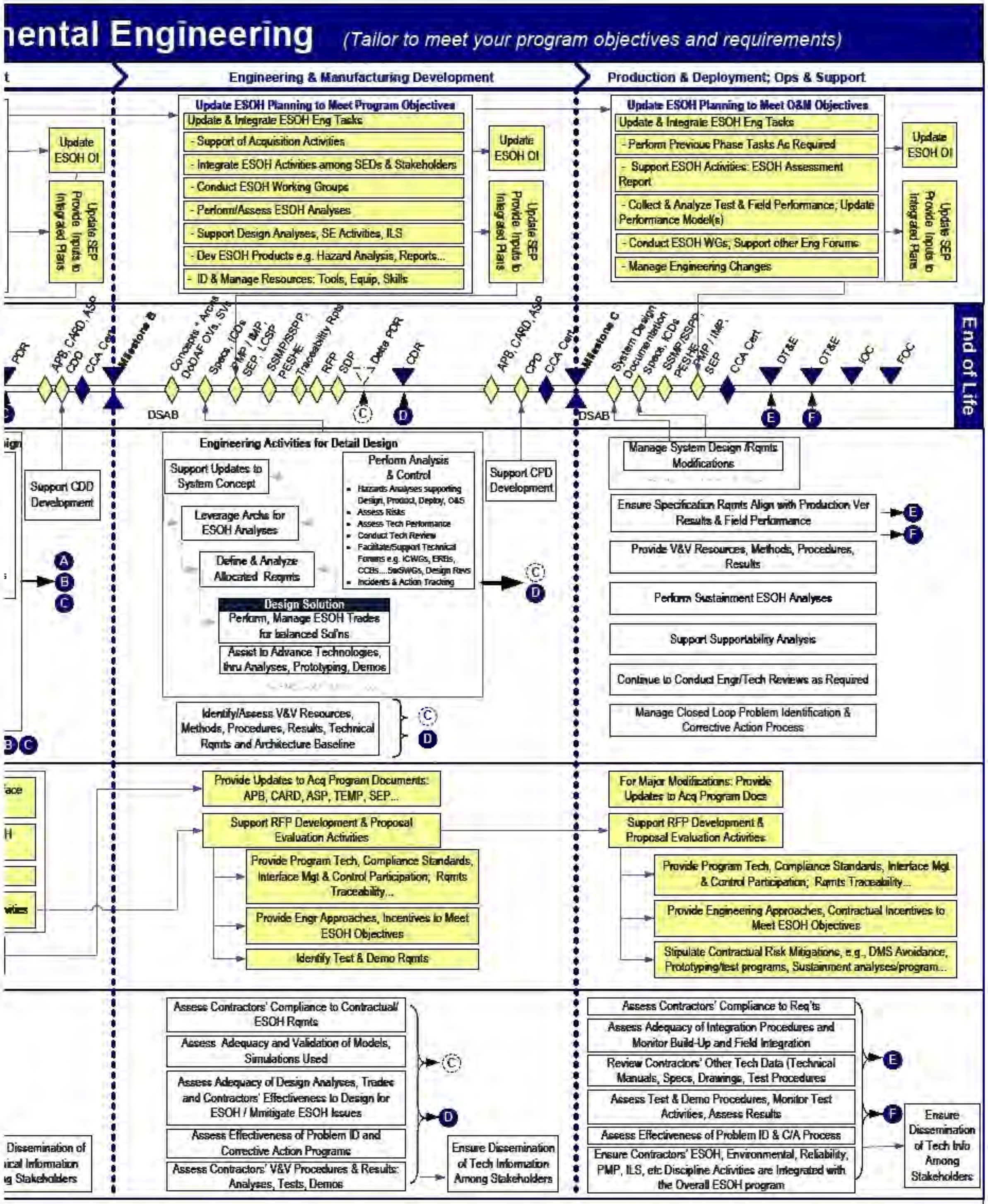


Figure 26 Acquisition life cycle process for SMC Environmental Engineering



ental Engineering (Tailor to meet your program objectives and requirements)
Engineering & Manufacturing Development
Production & Deployment; Ops & Support
Update ESOH OI
Update SEP Provide Inputs to Integrated Plans
Update ESOH Planning to Meet Program Objectives
Update & Integrate ESOH Eng Tasks
- Support of Acquisition Activities
- Integrate ESOH Activities among SEDs & Stakeholders
- Conduct ESOH Working Groups
- Perform/Assess ESOH Analyses
- Support Design Analyses, SE Activities, ILS
- Dev ESOH Products e.g. Hazard Analysis, Reports...
- ID & Manage Resources: Tools, Equip, Skills
Update ESOH Planning to Meet O&M Objectives
Update & Integrate ESOH Eng Tasks
- Perform Previous Phase Tasks As Required
- Support ESOH Activities: ESOH Assessment Report
- Collect & Analyze Test & Field Performance; Update Performance Model(s)
- Conduct ESOH WGs; Support other Eng Forums
- Manage Engineering Changes
End of Life
PDR
APB, CARD, ASP
CDD
CCA Cert
Milestone B
Concepts + Archs
DoDAF OVs, SVs
Specs, ICDs
PMP / IMP, SEP, LCSP
SSMP/SSPP, PESHE
Traceability Rqts
RFP
SDP
Delta PDR
CDR
APB, CARD, ASP
CPD
CCA Cert
Milestone C
System Design Documentation
Specs, ICDs
SSMP/SSPP, PESHE
IMP / IMP, SEP
CCA Cert
OT&E
OT&E
IOC
FOC
DSAB
DSAB
Support CDD Development
Engineering Activities for Detail Design
Support Updates to System Concept
Leverage Archs for ESOH Analyses
Define & Analyze Allocated Rqmts
Perform Analysis & Control
Hazards Analyses supporting Design, Product, Deploy, O&S
Assess Risks
Assess Tech Performance
Conduct Tech Review
Facilitate/Support Technical Forums e.g. ICWGs, ERBs, CCBs...SwSWGs, Design Revs
Incidents & Action Tracking
Design Solution
Perform, Manage ESOH Trades for balanced Sol'ns
Assist to Advance Technologies, thru Analyses, Prototyping, Demos
Support CPD Development
Identify/Assess V&V Resources, Methods, Procedures, Results, Technical Rqmts and Architecture Baseline
Manage System Design /Rqmts Modifications
Ensure Specification Rqmts Align with Production Ver Results & Field Performance
Provide V&V Resources, Methods, Procedures, Results
Perform Sustainment ESOH Analyses
Support Supportability Analysis
Continue to Conduct Engr/Tech Reviews as Required
Manage Closed Loop Problem Identification & Corrective Action Process
Provide Updates to Acq Program Documents: APB, CARD, ASP, TEMP, SEP...
Support RFP Development & Proposal Evaluation Activities
Provide Program Tech, Compliance Standards, Interface Mgt & Control Participation; Rqmts Traceability...
Provide Engr Approaches, Incentives to Meet ESOH Objectives
Identify Test & Demo Rqmts
For Major Modifications: Provide Updates to Acq Program Docs
Support RFP Development & Proposal Evaluation Activities
Provide Program Tech, Compliance Standards, Interface Mgt & Control Participation; Rqmts Traceability...
Provide Engineering Approaches, Contractual Incentives to Meet ESOH Objectives
Stipulate Contractual Risk Mitigations, e.g., DMS Avoidance, Prototyping/test programs, Sustainment analyses/program...
Assess Contractors' Compliance to Contractual/ ESOH Rqmts
Assess Adequacy and Validation of Models, Simulations Used
Assess Adequacy of Design Analyses, Trades and Contractors' Effectiveness to Design for ESOH / Mitigate ESOH Issues
Assess Effectiveness of Problem ID and Corrective Action Programs
Assess Contractors' V&V Procedures & Results: Analyses, Tests, Demos
Ensure Dissemination of Tech Information Among Stakeholders
Assess Contractors' Compliance to Req'ts
Assess Adequacy of Integration Procedures and Monitor Build-Up and Field Integration
Review Contractors' Other Tech Data (Technical Manuals, Specs, Drawings, Test Procedures
Assess Test & Demo Procedures, Monitor Test Activities, Assess Results
Assess Effectiveness of Problem ID & C/A Process
Ensure Contractors' ESOH, Environmental, Reliability, PMP, ILS, etc Discipline Activities are Integrated with the Overall ESOH program
Ensure Dissemination of Tech Info Among Stakeholders
Dissemination of ...ical Information ...g Stakeholders

2. **Technology Development.** The Environmental Engineer prepares the initial PESHE and an updated MS B PESHE to include the NEPA Strategy. Environmental Engineer provides inputs to and supports all program acquisition activities to include the development of the acquisition strategy, updates to the cost model and development of the Cost Analysis Requirements Description (CARD), solicitation/RFP development and proposal evaluation activities. The Environmental Engineer identifies other environmental related contract requirements, environmental related tasks, test & demo requirements to meet environmental engineering objectives. The Environmental Engineer also contributes to the development and updates to the TD Phase acquisition products.

TD Phase – SMC Acquisition Products
Updates to ASP, TDS, DMS
LC Cost Estimate Update / CARD Development
RFP: ESOH objectives in the SOO; ESOH related tasks in SOW, ESOH data products in CDRLs; SMC-Environmental standards - tailored
PESHE (Including NEPA strategy)
APB: ESOH objectives & related concept descriptions
Detailed ESOH planning HMMP, SSMP / SSPP; SEP, LCMP, LCSP, TEMP, PDR SDAR

3. **Engineering & Manufacturing Development.** The Environmental Engineer provides inputs to and supports all program acquisition activities to include updates to the acquisition strategy and updates to the cost model to reflect the actual technical solutions determined and updates to the CARD. Environmental Engineer supports the solicitation/RFP development and proposal evaluation activities which include providing the technical inputs including technical requirements, compliance standards, engineering approaches, incentives, and warranty programs to meet program objectives. The Environmental Engineer identifies other contract requirements as necessary to meet environmental engineering objectives. Environmental Engineer also contributes to the development and updates to the EMD Phase acquisition products.

EMD Phase – SMC Acquisition Products
Updates to ASP, TDS, DMS
CARD update
RFP: ESOH objectives in the SOO; ESOH related tasks in SOW, ESOH data products in CDRLs; SMC-Environmental Engineering standards - tailored
HMMP; SSMP / SSPP; PESHE, NEPA
APB: ESOH objectives & related concept descriptions
Detailed ESOH planning, SEP, LCMP, LCSP, TEMP updates, D&D Planning, Preliminary EOLP, CDR SDAR
HMMP; SSMP / SSPP; PESHE
APB: ESOH objectives & related concept descriptions
Detailed ESOH planning, SEP, LCMP, TEMP updates

During EMD the Environmental Engineer documents hazardous materials in the Programmatic Environment, Safety, and Occupational Health Evaluation (PESHE) and ensures that the SMC Program Office estimates and plans for the system's demilitarization and safe disposal. The demilitarization of energetic materials (including any item containing propellants, explosives, or pyrotechnics) must be considered during system design.

P&D / O&S Phase – SMC Acquisition Products
Updates to ASP, TDS, DMS
RFP: ESOH objectives in the SOO; Safety related tasks in SOW, ESOH data products in CDRLs; SMC-Safety standards - tailored
HMMP; SSMP / SSPP; PESHE
Detailed ESOH planning, SEP, LCMP, LCSP, TEMP updates, Final SDAR, Draft EOLP
CARD update

4. **Production & Deployment, Operations & Support.** The Environmental Engineer provides inputs to and supports all program acquisition activities to include updates to the acquisition strategy and updates to the cost model to reflect the actual technical solutions determined and updates to the CARD. The Environmental Engineer supports the solicitation/RFP development and proposal evaluation activities. The Environmental Engineer identifies other contract requirements: production and field test & demo requirements; field performance and sustainment analyses to meet Environmental Engineering objectives. At the end of its useful life, the Environmental Engineer ensures that the system is demilitarized and disposed of in accordance with all legal and regulatory requirements and policy relating to ESOH (including explosives hazards), security, and the environment.

Environmental Engineers' Contributions to Engineering Life Cycle Framework

Relationship to the SE Organization

The Environmental Engineer plans and executes the essential environmental engineering and engineering management efforts in an integrated and effective manner within the context and full support of the overarching Systems Engineering function. The Environmental Engineer ensures that their SED contributions are timely, adequate, consistent, and compliant. The Environmental Engineer ensures that their contributions are channeled through the Systems Engineering *Analyses and Control* activity.

Systems Engineers manage the engineering process and activities depicted in Figure 3 while the Environmental Engineer contributes to this process. Environmental Engineers support concept and architecture development and analyses; modeling and simulation efforts; technology studies when potentially impacted environmental challenges. The Environmental Engineers develop/derive ESOH related requirements and supports the requirements analyses and allocations process. They also participate in technical studies and technical solutions trades when environmental engineering is a factor. They provide design analyses contributions to determine potential hazards. They assess and propose alternative mitigating actions or solutions. The Environmental Engineer also works closely with the System Engineers performing interface analyses and functional analyses to leverage the required ESOH related analyses. The Environmental Engineer also supports the integration and verification and validation planning and execution.

In performing the management and control function, the Systems Engineer effectively integrates all engineering functions through the full system life cycle. The Environmental Engineer ensures their technical contribution to the overall engineering advances and is appropriately applied through systematic control, collaboration and sharing across the organization. For example, their assessment products, e.g., hazards assessments, are timed to coincide with architectural trades, design trades, reliability analyses (fault tree, failure modes, critical items lists, reliability block diagrams, etc). In addition the Environmental Engineering products are timed and applied by the other Specialty Engineers to perform their unique contributions, and must be provided to technical and program management for decision making.

Relationship to other SEDs

The Environmental Engineer SED relationship to other SEDs is summarized in Figure 1. Environmental Engineer interactions with the other SEDs are critical to perform and integrate their engineering contributions to the system development efforts.

Environmental Engineers team with the System Safety Engineers and Reliability Engineers to perform system hazards analyses to determine items or functions when performed or whose failure could lead to a hazardous system state -- one that could result in unintended death, injury, loss of property, or environmental harm).

Environmental Engineers work closely with Human Systems Integration to design systems that can be operated and maintained by users; and are habitable and safe with minimal environmental and occupational health hazards. When failure analyses results indicate potential hazards impacts, the Environmental Engineer assists to adjust reliability allocations and ensure confidence in attaining ESOH requirements through analyses, demo, and test. Figure 16 illustrates how the Environmental Engineer contributes to the analyses and integrates that effort with the Systems Engineer, Safety Engineer, Reliability Engineer, and Risk Manager. The Environmental Engineer works closely with the Logistics Engineers performing maintenance and sustainment analyses to identify and address hazards related issues or risks.

Tools Selection and Use

The Environmental Engineer considers effectiveness and efficiencies gained by selecting and using the best choice of Environmental Engineering tools considering the ESOH tool requirements possibly for hazards analyses, information sharing, automated data exchanges with other tools, and other considerations.

Typical Environmental Engineering Functions Requiring Tools
Hazards identification, analyses & reporting
Incidents & action tracking
Fault tree, failure modes; probabilistic failure analyses (See RAM SED)

Engineering Activities and Products over the Life Cycle

Engineering activities that are unique to environmental engineering include:

- Identify, evaluate, and control hazards throughout the system's life cycle.
- Define and document mishap risk levels including associated mishap risk acceptance processes.
- Establish a program that manages and documents the probability and severity of all hazards associated with development, use and disposal of the system.
- Manage all ESOH risks in a manner that is cost effective and consistent with mission requirements.
- Ensure that mandated environmental requirements are established and implemented for all space systems. Environmental Engineering includes the control and minimization of hazards related to orbital debris, collision avoidance, laser clearing-house functions, environmental hazards, and safety procedures.
- Align with the System Safety Engineers to establish an explosives safety program that ensures munitions, explosives, and energetics are properly hazard classified, and safely developed, manufactured, tested, transported, handled, stored, maintained, demilitarized, and disposed. Comply with DoD explosives safety requirements in all acquisition programs that include or support munitions, explosives, or energetics. Evaluate and manage the use and selection of energetic materials and the design of munitions and explosive systems to reduce the possibility and the consequences of

any munitions or explosives mishap to optimize the trade-off of munitions reliability against unexploded ordinance liability.

Environmental Analysis and Impact Assessment. An environmental analysis is performed to determine the impact on and by each system product and process alternative. Proposed environmental-related tradeoffs and analyses are presented through the System Engineering process to determine balanced technical solutions which the Environmental Engineer is a part of.

The Environmental Engineer ensures adherence to all applicable statutes and to contractually designated hazardous material lists; analyzes factors such as noise pollution, quantities and types of hazardous materials used, hazardous waste disposal, and other defined environmental requirements as applicable; defines and assesses methods to mitigate problems and impacts identified from this analysis; includes the results of these assessments into effectiveness analyses as well as system definition, design, and verifications; documents analysis output appropriate to the acquisition phase and use in conjunction with cost and performance analyses outputs to support acquisition phase exit criteria; avoids use of materials that present a known hazard to the environmental; includes environment-critical characteristics of people, product, and process solutions, and their risks included in risk management process.

Disposal Analysis and Assessment. The Environmental Engineer contributes disposal analyses and assessments to support development of people, product, and process solutions to dispose of products and by-products. Proposed disposal-related tradeoffs and other analyses are presented through the System Engineering process to determine balanced technical solutions which the Environmental Engineer is a part of.

The Environmental Engineer identifies environmental factors for process waste and output as well as used products and components; evaluates effective disposal methods for system parts and materials and requirements for new or modified methods, including storage, dismantling, demilitarization, reusing, recycling, and destruction; identifies costs, sites, responsible agencies, handling and shipping, supporting items, and applicable federal, state, local, and host nation regulations as factors, and includes disposal-critical characteristics of people, product, and process solutions and their risks in the program risk management process.

The following subsections delineate Environmental Engineer contributions to engineering activities and technical products by DOD acquisition phase.

1. **Materiel Solution Analysis.** During this phase the Environmental Engineer may provide inputs to and support the Capabilities Based Assessment process and the JCIDS process. The Environmental Engineer evaluates proposed concepts and architectures to identify and assess implications of energetic materials, explosives, hazardous materials and provide recommendations for each alternative. The Environmental Engineer assists to define / refine ESOH related requirements to support ICD development and possibly TRD development. The Environmental Engineer also contributes to the development of the MSA Phase technical products.

MSA Phase – Technical Products Required	
SMC ESOH Technical Products	**ESOH Contributions to Other Organizations' Products**
High level assessment proposed concepts & architectures	Operational Concepts
Environmental engineering inputs and factors for concept, architecture, technology studies, and trades	AoA Studies
ESOH Req'ts (draft)	Initial Capabilities Doc (ICD) Dev
Roadmap and architectural inputs – Identification & mitigations of potential hazards	DoDAF CVs, OVs

2. **Technology Development.** During this phase the Environmental Engineer continues to provide inputs to and supports the JCIDS process. The Environmental Engineer also supports all the engineering activities highlighted within the box titled *Engineering Activities for System & Segment Development & Design* Figure 26 to commence system definition and development. Environmental Engineer develops and contributes to development of the TD Phase technical products.

TD Phase – Technical Products Required	
SMC ESOH Technical Products	**ESOH Contributions to Other Organizations' Products**
Inputs to System Concepts	Operational Concepts
Factors for Studies/ Trades	Operational Assessments
ESOH Tech Req'ts, TRD, SRD, Specifications, ICDs, Standards Selection/ Tailor	Capabilities Development Doc (CDD)
ESOH inputs to ISP	DoDAF CVs, OVs
Prelim hazards list	
PESHE	

3. **Engineering & Manufacturing Development.** Environmental Engineer continues to provide inputs to and supports the JCIDS process. The Environmental Engineer supports all the engineering activities highlighted within the box titled *Engineering Activities for Detailed Design* Figure 26 to commence detailed systems definition and development. The Environmental Engineer ensures process is in place to report, analyze, and mitigate hazards data during DT&E. The Environmental Engineer provides inputs to and supports the JCIDS process. The Environmental Engineer develops and contributes to the development of the EMD Phase technical products.

EMD Phase – Technical Products Required	
SMC ESOH Technical Products	**ESOH Contributions to Other Organizations' Products**
Update System Concept	Operational Concepts
Technical Studies/ Trades	Operational Assessments
System Tech Req'ts, TRD, SRD, Spec, ICDs; ESOH requirements flow-down / allocations	Capabilities Production Doc (CPD)
Inputs to system design, production, fielding, sustain docs	DoDAF CVs, OVs
PESHE Update	
Environmental Eng inputs to ISP	
Hazards analyses/report	
ESOH evaluations of Tech Orders, operations manuals	
Test, Demo reports	

4. **Production & Deployment, Operations & Support.** The Environmental Engineer continues to ensure design meets the contractual environmental engineering requirements and manufacturing, build and integration activities do not induce additional hazard risks. The Environmental Engineer ensures the ESOH program appropriately addresses end-of-life safing, and space environments per AFSPC Supplement to AFI 91-202. The Environmental Engineer develops and contributes to the development of the Production & O&S Phase technical products.

P&D / O&S Phase – Technical Products Required	
SMC ESOH Technical Products	**ESOH Contributions to Other Organizations' Products**
Inputs tech baseline engineering changes	Supportability assessment Rpt Contribution
Analyses of failures and mishap incidents	Operational Assessments Contributions
Hazards analyses Report.	Transition & Fielding Docs
PESHE Update	
T&E / Demo, ESOH Reports	
ESOH evaluations of Tech Orders, operations manuals	

Environmental Engineers' Contributions to Program and Project Management

Each SMC program defines their business model and approach structure based primarily on their program objectives, program and technical challenges, organizational structure, as well as program and engineering planning (SEP plus detailed ESOH planning (HMMP/SSMP/SSPP)).

The Environmental Engineer develops and implements the environmental engineering program planning to achieve Program Office environmental engineering objectives and requirements. The planning defines the ESOH tasks and functions to be performed and products to be developed; timing of tasks, task outputs, resources (skills, tools, equipment, and completion criteria). The Environmental Engineer plans tasks to integrate ESOH activities within the Program Office, between Contractors and stakeholders. The Environmental Engineer plans the tasks to establish and manage hazards; conduct hazards review forums; support SE&I activities, risk management, integration, and system modifications; coordinate the ESOH planning with SMC Staff Environmental Engineering office, integrate environmental engineering planning with other functional and acquisition plans (i.e. SSMP, SEP, ASP, LCMP).

Execution of the Environmental Engineer planning is typically defined through an Operating Instruction which implements SMC and higher level instructions, policies, and directives. The Environmental Engineer provides full support to define the program and technical objectives where ESOH challenges and risks are known or anticipated. The Environmental Engineer assists to establish the business model, develop program planning and schedules, and define and implement program processes. The Environmental Engineer ensures the ESOH components of the program are appropriately represented in the program plans, program schedules, work breakdown schedules, cost estimates. The Environmental Engineer also reports their technical performance and progress. The Environmental Engineer shares in the risk management responsibilities to identify, assess, and propose mitigating actions of ESOH related risks. They also support the program manager's problem identification, resolution, and decision-making processes.

The Environmental Engineer contributes to the development of the program management products identified in the Table.

SMC Program Management Products
PMD
SEP, IMP, IMS, WBS
Decision-making & problem solving inputs
Technical progression and issues reporting
LC Cost Estimate (CARDs)
Processes (OIs)
Risk Management Inputs

Appendix U – Prognosis, Diagnostics (Prognostics) & Health Management (PHM) Engineering

Since the 1960s, most electronic military equipment associated with space and airborne systems has been developed with built-in-test (BIT) capability. BIT capability typically provides:

- Fault detection
- System (or equipment) response to the fault
- Fault event warning and/or logging to aid in troubleshooting

More sophisticated BIT designs can be characterized as *passive* fault diagnostics and management intended mostly for airborne systems to support the maintenance process. For our launch, space and missile systems, unique constraints (remote systems, minimal event response time, autonomous safety, harsh environments) drive the need for more sophisticated and autonomous PHM. Hence, our space systems now demand *active* fault management system designs to provide automated and high fidelity prognostics of system hardware and software and can take proactive measures to correct faults autonomously. The table below summarizes common PHM capabilities that are designed into our space, launch, and missile systems.

System	Typical PHM Capabilities
Spacecraft	Spacecraft PHM capabilities include autonomous health and operations monitoring and control; power and attitude control monitoring with automated systems reset and restart; transmitter and receiver and communication link tests; automatic reset features to restart remote computers.
Launch Systems	Pre-launch failure detection, notification, and response for abort determination; command destruct /self-destruct; stage event monitoring and diagnostics; communication systems link tests
Missile systems	Pre-launch failure detection, notification, and response for abort determination; command destruct /self-destruct; stage event monitoring and diagnostics. Minuteman Missile was one of the first major weapons systems designed and fielded with computer-controlled BIT systems
Safety-critical devices	Safety devices self-test to assure their continued operations. Normally there are two tests. A power-on self-test to perform device diagnostics. Then periodic tests to assure that device have not become unsafe since the power-on self-test.
Computers & Application Software	The typical personal computer tests itself at start-up with the BIOS power-on self-test. Most computers, including embedded systems, have self-tests of the processor(s), memory and application software.
Integrated Circuits	In integrated circuits, BIT is used to make faster, less-expensive manufacturing tests.
Other Components	Prognostics are designed into insulated gate bipolar transistor (IGBT), embedded capacitors, FPGAs, resettable fuses, to name a few

Developing and designing PHM sub-systems follows the engineering requirements, and practices summarized in SMC –S-001, SMC-G-001, and the SMC Systems Engineering Handbook. In summary, the PHM sub-system is first conceptualized and architected based on the required operational and sustainment capabilities and established constraints. The PHM subsystem design is then increasingly characterized based on system and allocated requirements, technical solutions trades results, and top-down (e.g., fault tree) and bottom-up (failure modes) failure analyses.

To be specific, as the system design is engineered, failure precursors, which indicate changes in a measured variable that can be associated with impending failure, are systematically identified. An active PHM design solution includes automated monitoring of the failure precursors, prognostics, and fault correction.

PHM provides the capability to make intelligent, informed, and appropriate decisions relating to system faults within and across systems during system development, integration & test, and operations & sustainment. A solid PHM program will also provide cost savings over the system life-cycle.

Key attributes of PHM include real time or near real time health status availability; proactive advisory generation based on health state; autonomic logistics (reduced human interaction); no or minimal false alarms; and autonomous fault management to preclude safety mishaps, performance degradation, and catastrophic failures. The SMC Program Office designated PHM Engineer will likely be responsible to:

- Lead or facilitate the conceptualization and architectural development of the PHM sub-system and elements
- Ensure adequacy of the system requirements analyses and allocations of the required PHM related capabilities.
- Support technical solutions trades and supporting PHM analyses for optimal and cost effective solutions.
- Ensure implementation of the PHM requirements and identify and remedy common gaps and barriers to achieving PHM
- Ensure establishment, implementation, and V&V of the PHM design baseline

The PHM Engineer plans and executes the essential PHM engineering and management efforts in an integrated and effective manner to ensure that PHM contribution is timely, adequate, consistent, and compliant. The PHM Engineer ensures that their contributions are channeled through the Systems Engineering *Analyses and Control* activity.

Applicable governance, standards, and guidance

Policy, directives, and instructions that mandate SMC PHM engineering related program requirements are included in a wide range of mandates including those providing requirements for acquisition, systems engineering, reliability, maintainability, T&E, system safety, and others.

DoD Instruction 5000.02 directs the effective sustainment of systems resulting from the design and development of reliable and maintainable systems. The operational readiness is optimized via "diagnostics, prognostics, and health management techniques in embedded and off-equipment applications when feasible and cost-effective".

DOD Instruction 4151.22 instructs the application and integration of appropriate processes, technologies, and knowledge based capabilities through Condition Based Maintenance (CBM) to improve the reliability and maintenance effectiveness of DoD systems and components. The CBM strategy includes implementing an optimum mix of maintenance technologies (e.g., diagnostics and prognostics) along with low ambiguity fault detection, isolation and prediction.

The standards provide requirements and guidelines for conducting research, development, and implementation of PHM technology and PHM design. PHM design standards are often specific to the technology, Line-Replaceable Unit (LRU) type, software application type, and device. Hence, they are largely determined during the system development and design process.

Table 26 Governance, standards, and guidance that shape the Prognostics Health Management discipline

Document No	Governance Title	Issue
DOD Instruction 5000.02	Operation of the Defense Acquisition System	08 Dec 08
DODI 4151.22	Condition Based Maintenance Plus (CBM+) for Materiel Maintenance	02 Dec 07
AFI 63-1201	Life Cycle Systems Engineering	23 Jul 07
AFI 10-602	Determining Mission Capability And Supportability Requirements	18 Mar 05
Document No	**Standards Title**	**Issue**
SAE JA1012	A Guide to the Reliability-Centered Maintenance (RCM) Standard	01 Jan 02
MIL-STD-810G	DoD Test Method Standard: Environmental Engineering Considerations And Laboratory Tests	31 Oct 08
MIL-STD-883H	DoD Test Method Standard: Microcircuits	26 Feb 10
IEEE 1149.1	Standard Test Access Port and Boundary-Scan Architecture	Jan 01
IEEE-1149.4	Mixed-Signal Test Bus	Apr 99
IEEE-1149.6	Boundary-Scan Testing of Advanced Digital Networks	Jun 03
Document No	**Guidance Title**	**Issue**
IEEE 1149.1 Primer	(JTAG) Testability Primer	
	OSC LCSP Template	25 Jul 09
	DoD Guide For Achieving Reliability, Availability, And Maintainability	03 Aug 05
IEEE 1232-1995	IEEE Standard for Artificial Intelligence and Expert System Tie to Automatic Test Equipment (AI-ESTATE): Overview and Architecture	21 Sep 95

PHM Engineers' Contributions to tbe Acquisition Life Cycle Framework

The DoD acquisition life cycle is defined by DoDI 5000.02. The PHM Engineer contributions over this life cycle are best represented within the phase of acquisition. Figure 27 provides the acquisition life cycle framework within which PHM Engineers perform as well as the products that the PHM Engineers must develop or contribute to their development. The SMC Program Office PHM Engineer establishes and implements PHM program strategies and objectives consistent with the tenets of appropriate policies, SMC acquisition objectives, and program objectives. The Program Office PHM Engineer then develops, attains approval for, and implements PHM planning into the Systems Engineering Plan (SEP) and higher level integrated planning (e.g., IMP) in accordance with current DoD policy. This planning is firmly based on program and technical objectives, strategies, DoD mandates, and instructions.

An effective PHM program supports all of the major acquisition activities through the full system life cycle. The planning sufficiently defines the PHM program to achieve the PHM and overall program objectives/goals and requirements; specifies tasks and functions to be performed, timing of tasks, resources required, products to be developed, and forms the basis for the development of the program PHM Operating Instruction (OI). The PHM planning and OI are then reflected appropriately in the WBS, IMS, and other program documents that address PHM related elements. The PHM planning is executed concurrently with the Program Office OI that documents the process to perform, control, and integrate all PHM engineering and management activities for each phase of acquisition. The SMC Program Office PHM planning (usually contained in the SEP and the detailed PHM program planning) and OI are to be based upon the appropriate program-approved life cycle. SMC Program Offices establish and implement PHM program strategies and objectives consistent with the tenets of appropriate policies, SMC acquisition objectives, and program objectives.

1. **Materiel Solution Analysis.** During this phase the PHM Engineer provides inputs to and supports program acquisition activities to include the development of the acquisition, technology demonstration, test strategies, inputs to the cost estimates, solicitation/RFP development for Contractor studies, and proposal evaluation activities. The PHM Engineer also contributes to the development of the MSA Phase acquisition products.

MSA Phase - SMC Acquisition Products
ASP, TDS, DMS, TES
LC Cost Estimate
APB, CCA Inputs; Stated Goals for PHM tempered with Affordability
SSP PHM Goals for System & Subsystem level
SEP, LCMP, LCSP Inputs, Early Concept Development Inputs, Cost & Schedule Inputs

2. **Technology Development.** The PHM Engineer provides inputs to and supports program acquisition activities to include the development of the acquisition strategy, updates to the cost model and development of the Cost Analysis Requirements Description (CARD), solicitation/RFP development and proposal evaluation activities.

   The PHM Engineer supports the development of the acquisition, technology demonstration, and test strategies to ensure successful implementation of PHM capabilities. PHM strategies are likely integral to the Reliability Availability Maintainability (RAM), and test strategies as well as strategies to achieve autonomous system performance

   The PHM Engineer supports the definition of contract requirements such as PHM performance work statements and specification requirements associated with application software performance, development, and qualification to meet the system or enterprise level PHM requirements and capabilities.

   The PHM Engineer also supports the definition of incentives programs as well as PHM related requirements for T&E, reliability, and maintainability. The PHM Engineer contributes to the development and updates to the TD Phase acquisition products.

TD Phase - SMC Acquisition Products
Updates to ASP, TDS, DMS, TES
LC Cost Estimate Update / CARD Development
PHM Operational & System Requirements; PHM Analyses Requirements; Data Requirements for PHM Design, Specialty Tools & Skill Sets Required
RFP: PHM objectives in the SOO; PHM related tasks in PWS, PHM data products in CDRLs; SMC- PHM standards - tailored
SSP: evaluation criteria for PHM
APB: PHM objectives & related concept descriptions
Detailed PHM planning, SEP, LCMP, LCSP, TEMP, Concept Development Inputs, PHM Technologies, Cost & Schedule Inputs

3. **Engineering & Manufacturing Development.** The PHM Engineer provides inputs to and supports program acquisition activities to include updates to the acquisition strategy and updates to the cost model to reflect the actual technical solutions determined and updates to the CARD.

   The PHM Engineer supports the development of the acquisition, technology demonstration, and test strategies to ensure successful implementation of PHM capabilities. PHM strategies are likely integral to the RAM, and test strategies as well as strategies to achieve autonomous system performance. The strategies now extend to implementation of PHM design constraints determined through system trades and engineering analyses.

EMD Phase - SMC Acquisition Products
Updates to ASP, TDS, DMS, TES
CARD update
RFP: PHM objectives in the SOO; PHM related tasks in SOW, PHM data products in CDRLs; SMC- PHM standards - tailored
SSP: evaluation criteria for PHM
APB: PHM objectives & related concept descriptions
Detailed PHM planning, SEP, LCMP, TEMP updates

The PHM Engineer supports the definition of contract requirements such as PHM performance work statements and specification requirements, and detailed design specification requirements associated with application software performance, development, and qualification to meet the system or enterprise level PHM requirements and capabilities.

The PHM Engineer supports the RFP development and proposal evaluation activities which include providing the technical inputs including technical requirements, compliance standards, engineering approaches, and incentives programs to meet program objectives.

The PHM Engineer also supports the definition of incentives programs, T&E, RAM requirements. The PHM Engineer also contributes to the updates to the TD Phase acquisition products.

Produce/O&S - SMC Acquisition Products
Updates to ASP, TDS, DMS, TES
RFP: PHM objectives in the SOO; PHM related tasks in SOW, PHM data products in CDRLs; SMC- PHM standards - tailored
SSP: evaluation criteria for PHM
Detailed PHM planning, SEP, LCMP, LCSP, Test Planning Updates
CARD update

4. **Production & Deployment, Operations & Support.** The PHM Engineer provides inputs to and supports program acquisition activities to include updates to the acquisition strategy and updates to the cost model to reflect the actual technical solutions determined and updates to the CARD. The PHM Engineer supports the solicitation/RFP development and proposal evaluation activities. The PHM Engineer identifies other contract requirements: incentives programs; production and field test & demo requirements; and field performance and sustainment analyses to meet PHM objectives. The PHM Engineer ensures successful validation of the intended prognostics, diagnostics, and fault management capabilities through operational test and demonstration.

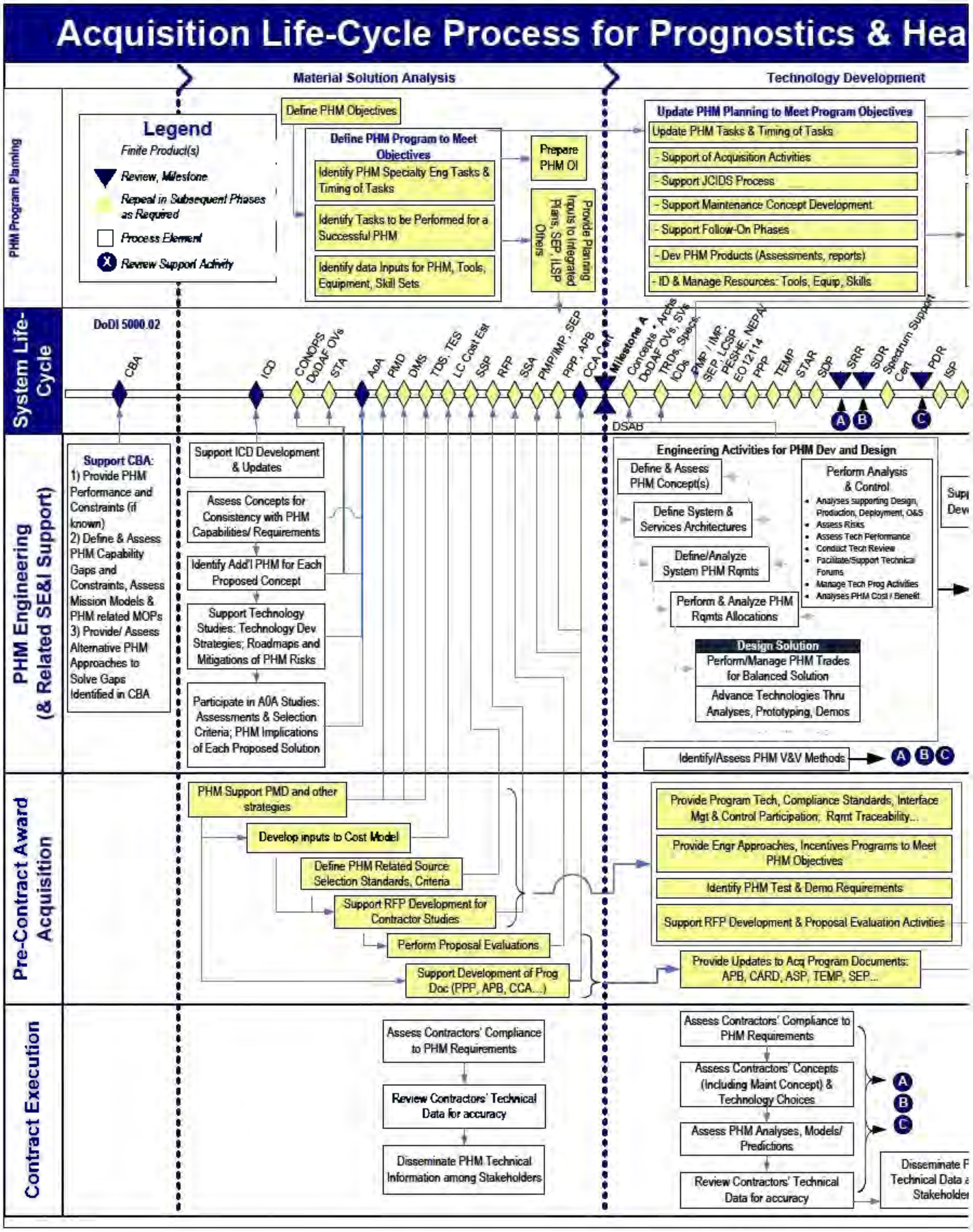
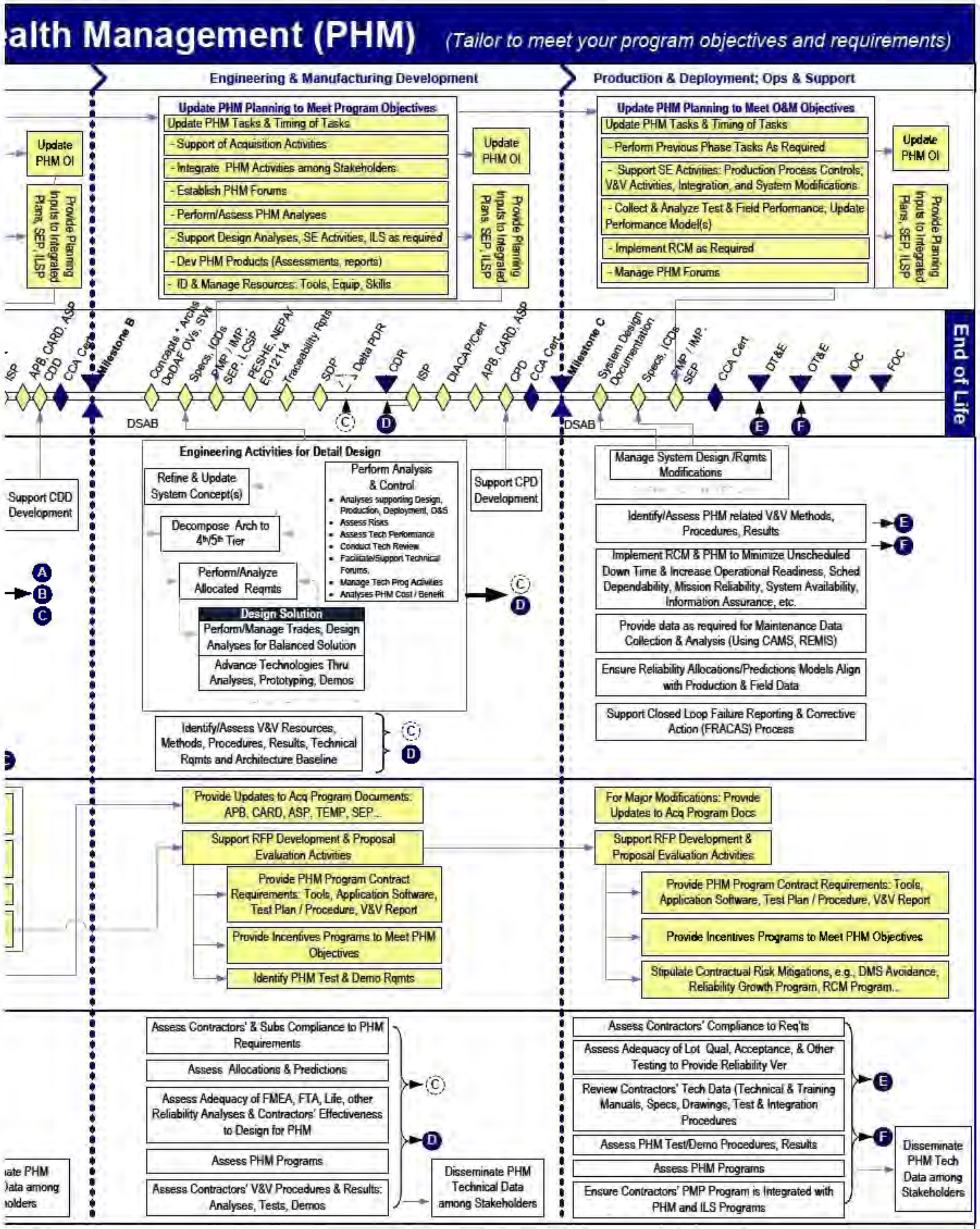


Figure 27 Acquisition life cycle process for SMC Prognostics & Health Management Engineering


alth Management (PHM) (Tailor to meet your program objectives and requirements)
Engineering & Manufacturing Development
Production & Deployment; Ops & Support
Update PHM OI
Provide Planning Inputs to Integrated Plans, SEP, ILSP
Update PHM Planning to Meet Program Objectives
Update PHM Tasks & Timing of Tasks
- Support of Acquisition Activities
- Integrate PHM Activities among Stakeholders
- Establish PHM Forums
- Perform/Assess PHM Analyses
- Support Design Analyses, SE Activities, ILS as required
- Dev PHM Products (Assessments, reports)
- ID & Manage Resources: Tools, Equip, Skills
Update PHM Planning to Meet O&M Objectives
Update PHM Tasks & Timing of Tasks
- Perform Previous Phase Tasks As Required
- Support SE Activities: Production Process Controls; V&V Activities, Integration, and System Modifications
- Collect & Analyze Test & Field Performance; Update Performance Model(s)
- Implement RCM as Required
- Manage PHM Forums
ISP
APB, CARD, ASP
CDD
CCA Cert
Milestone B
Concepts • Archs
DoDAF OVs, SVs
Specs, ICDs
PMP / IMP, SEP, LCSP
PESHE, NEPA/ EO12114
Traceability Rqts
SDP
Delta PDR
CDR
ISP
DIACAP/Cert
APB, CARD, ASP
CPD
CCA Cert
Milestone C
System Design Documentation
Specs, ICDs
PMP / IMP, SEP
CCA Cert
OT&E
OT&E
IOC
FOC
End of Life
DSAB
DSAB
Support CDD Development
Engineering Activities for Detail Design
Refine & Update System Concept(s)
Decompose Arch to 4th/5th Tier
Perform/Analyze Allocated Reqmts
Perform Analysis & Control
Analyses supporting Design, Production, Deployment, O&S
Assess Risks
Assess Tech Performance
Conduct Tech Review
Facilitate/Support Technical Forums,
Manage Tech Prog Activities
Analyses PHM Cost / Benefit
Design Solution
Perform/Manage Trades, Design Analyses for Balanced Solution
Advance Technologies Thru Analyses, Prototyping, Demos
Support CPD Development
Identify/Assess V&V Resources, Methods, Procedures, Results, Technical Rqmts and Architecture Baseline
Manage System Design /Rqmts Modifications
Identify/Assess PHM related V&V Methods, Procedures, Results
Implement RCM & PHM to Minimize Unscheduled Down Time & Increase Operational Readiness, Sched Dependability, Mission Reliability, System Availability, Information Assurance, etc.
Provide data as required for Maintenance Data Collection & Analysis (Using CAMS, REMIS)
Ensure Reliability Allocations/Predictions Models Align with Production & Field Data
Support Closed Loop Failure Reporting & Corrective Action (FRACAS) Process
Provide Updates to Acq Program Documents: APB, CARD, ASP, TEMP, SEP...
Support RFP Development & Proposal Evaluation Activities
Provide PHM Program Contract Requirements: Tools, Application Software, Test Plan / Procedure, V&V Report
Provide Incentives Programs to Meet PHM Objectives
Identify PHM Test & Demo Rqmts
For Major Modifications: Provide Updates to Acq Program Docs
Support RFP Development & Proposal Evaluation Activities
Provide PHM Program Contract Requirements: Tools, Application Software, Test Plan / Procedure, V&V Report
Provide Incentives Programs to Meet PHM Objectives
Stipulate Contractual Risk Mitigations, e.g., DMS Avoidance, Reliability Growth Program, RCM Program...
Assess Contractors' & Subs Compliance to PHM Requirements
Assess Allocations & Predictions
Assess Adequacy of FMEA, FTA, Life, other Reliability Analyses & Contractors' Effectiveness to Design for PHM
Assess PHM Programs
Assess Contractors' V&V Procedures & Results: Analyses, Tests, Demos
Disseminate PHM Technical Data among Stakeholders
Assess Contractors' Compliance to Req'ts
Assess Adequacy of Lot Qual, Acceptance, & Other Testing to Provide Reliability Ver
Review Contractors' Tech Data (Technical & Training Manuals, Specs, Drawings, Test & Integration Procedures
Assess PHM Test/Demo Procedures, Results
Assess PHM Programs
Ensure Contractors' PMP Program is Integrated with PHM and ILS Programs
Disseminate PHM Tech Data among Stakeholders

PHM Engineers' Contributions to the Engineering Life Cycle Framework

Relationship to the SE Organization

The PHM Engineer plans and executes essential PHM engineering efforts in an integrated and effective manner within the context and full support of the overarching Systems Engineering function. The PHM Engineer ensures that each PHM SED contribution is timely, adequate, consistent, and compliant. The PHM Engineer ensures that their contributions are channeled through the Systems Engineering Analyses and Control activity. Systems Engineers manage the engineering process and activities depicted in Figure 3 while the PHM Engineer contributes to this process. The PHM Engineer supports concept & architecture development and analyses; modeling and simulation efforts; and technology studies. The PHM Engineer develops/derives their requirements and supports the requirements analyses and allocations process. They also participate in technical studies and solutions trades when system availability, reliability, maintainability, survivability, system safety are a factor, minimizing unscheduled maintenance, extending maintenance cycles, and maintaining effectiveness through timely repair actions; reducing the life-cycle cost of equipment by decreasing inspection costs, downtime, and inventory; and improving qualification and assisting in the design and logistical support of fielded and future systems.

The PHM Engineer also works closely with the System Engineers to ensure PHM hardware & software architectural and design solutions are adequately represented in the system architecture. The PHM Engineer supports the System Engineers' requirements development activities to define requirements for development and design of the PHM related hardware, software, information exchange formats, integrity analyses, etc. The PHM Engineer aligns closely with the Reliability Engineer to perform failure analyses to determine failure precursors, define prognostics methods, and fault correction techniques.

In performing the management and control function, the PHM Engineer ensures their technical information advances and is appropriately applied through systematic control, collaboration and sharing across the organization. For example, their analytical products (e.g., determinations of passive verses active fault management solutions) must be timely fed back to the architectural development team, test team, and requirements team to perform their unique contributions, and must be provided to technical and program management for decision making.

Relationship to Other SEDs

The PHM Engineer ensures their technical contribution to the overall engineering advances and is appropriately applied through systematic control, collaboration and sharing across the organization. PHM Engineers products are timed and applied by the other Specialty Engineers to perform their unique contributions, and must be provided to technical and program management for decision making.

The PHM Engineer works closely with the Logistics Engineers to determine maintenance and maintainability requirements and technical solutions. Implementation of the PHM related requirements are initially conveyed in the maintenance concept and system architecture. The PHM Engineer collaborates with the Systems Engineer, Architecture Engineer, T&E Engineer, and Design Engineer to ensure the system architecture includes PHM related technology, physical and functional solutions that implement the maintainability requirements for built-in test and fault management requirements for real-time or periodic system integrity prognostics, health and/or fault reporting, and fault corrections (autonomous or man-in-the-loop).

The PHM Engineer supports the Reliability Engineer in the performance of the failure analyses to identify failure precursors and assist to determine design reliability solutions that may be partially achieved through application of PHM technologies, devices, and techniques. The PHM Engineer supports the T&E Engineer to determine alternative and cost effective test solutions that are balanced to also meet performance requirements and logistics, reliability, maintainability and other constraints.

The PHM Engineer supports the System Safety Engineer to identify requirements, viable technologies, and design solutions for safety systems and devices incorporating PHM such as safe and arm systems and command destruct devices.

Tools Selection and Use

The PHM Engineer considers effectiveness and efficiencies gained by selecting and using the best choice of PHM tools considering the PHM tool needs for fault data collection, analyses, reporting, and fault management.

Typical PHM Functions Requiring Tools
PHM Modeling and Architecture Development
PHM Requirements Analyses & Allocations
Fault Data Collection and Reporting
Prognostics and Health Management Analysis

Engineering Activities and Products over the Life Cycle

The following subsections delineate PHM contributions to engineering activities and technical products by DOD acquisition phase. The Program Office determines the full scope of PHM activities and products that are to prepared by the Program Office and their Contractors.

There are many aspects of the prognostics and health management that need to be addressed before successful implementation in any system. These include conceptualization and architectural development of the PHM subsystem or PHM elements; PHM requirements development; technology, architecture, and design solutions trades; and verification and validation of PHM specification requirements and required capabilities.

Built-in test of space system elements provides fault finding as a means to aid in system unit monitoring and diagnostics. BIT status is beneficial when failure occurrences can be rapidly isolated to a particular unit and equally useful when situations result in no-fault found and may be attributable to other conditions. The unit BIT provides the necessary BIT sensors and parametric test data from parametric sensors, to the system level PHM (application software) *manager* for diagnosing the root cause of failure and failure predictions (Prognostics).

In summary, effective PHM for a space system integrates unit, subsystem, and system level prognostics, health monitoring, and management strategies, consisting of diagnostic and prognostic technologies, with an integrated modeling architecture that addresses anomaly/failure mitigation to optimize performance and reduce life cycle costs.

A PHM system is capable of comprehensive failure mode diagnostic and prognostic approaches ranging from generic signal processing and experience-based algorithms to the more complex knowledge and model-based techniques. Prognostic approaches that apply to space systems also include:

- Reliability and Usage Based Prognostics
- Evolutionary-based Prognostics
- Data-Driven Prognostic Modeling

- Parameter Estimation Based Approach
- Physics-Based Approaches

A sample depiction of how this may be implemented is illustrated by Figure 28 below.

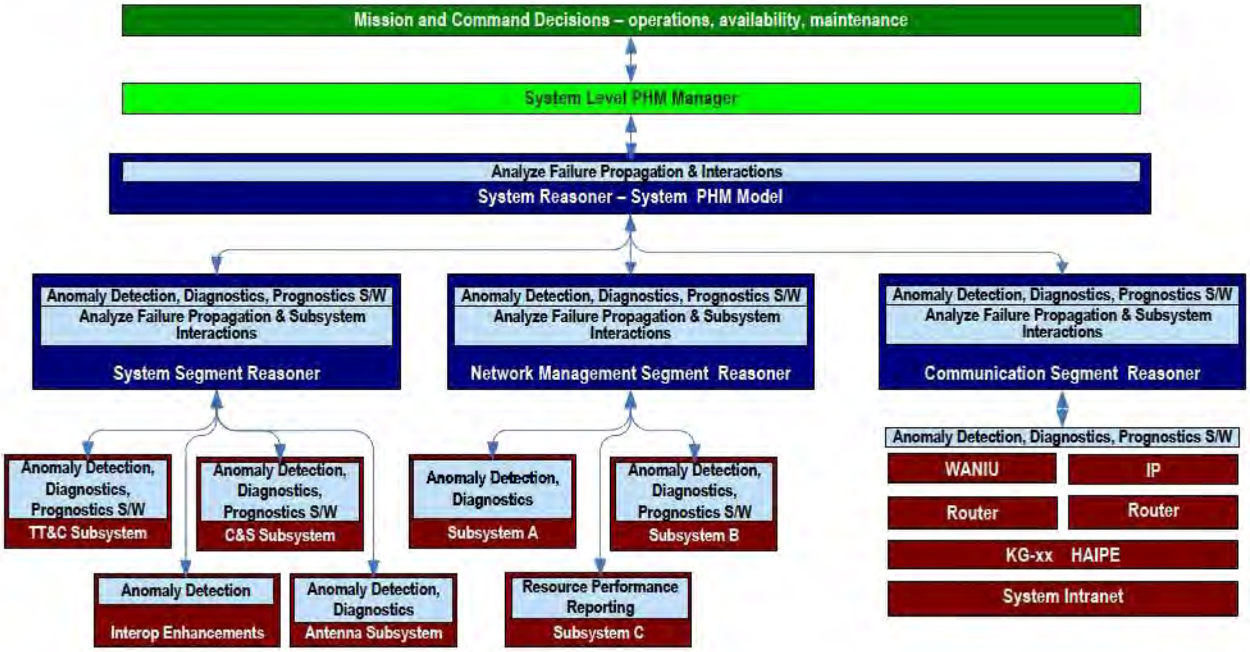


Figure 28 Conceptual illustration of PHM implementation on a satellite control system

Additional Functions of a PHM Manager. The System Level PHM Manager conceptually monitors an entire system status to identify hardware and software problems across the system. In addition, the System Level PHM Manager provides tools for filtering and correlating fault information, diagnosing problems, and resolving these problems efficiently. The System Level PHM Manager may opt to manage hardware and software of the system elements if they are not managed locally. System Level PHM Manager performs configuration management of all elements, services, and applications in a Services Oriented Architecture (SOA) based system. Deployment of a new software application is simply a deployment of a software package across the complete SOA-based system network for user consumption.

For launch systems recent launch failures have been attributed to fairing separation issues. Examples of BIT technology applied to launch system separation devices follow.

Laser or Light Emitting Diode Initiated Ordnance. Laser or built-in light emitting diodes are used to supply the initiation energy. These devices allow the simplification of factory integration and checkout due to its Built-in-Test (BIT) capability to verify system integrity of each initiator.

Intelligent Initiation System. EBA&D has developed an intelligent electronic initiation system (WizOrd®) based on a semiconductor bridge initiator. Employing a similar safe and arm architecture as laser or light emitting diode initiated ordnance, this intelligent system offers real time BIT and health monitoring while at the same time operating with much lower draw on vehicle power. Both attributes provide for enhanced reliability and cost for the overall vehicle.

Hence, the PHM Engineer ensures PHM considerations during early concept and technology development, identifies plausible solutions to system PHM methodologies and alternative technologies or devices for monitoring, data acquisition, data processing, algorithms for fault identification, fault isolation, failure prediction, remaining useful life estimation, testing, decision making for condition based maintenance, and fault correction.

1. **Materiel Solution Analysis.** During this phase the PHM Engineer may provide inputs to and support program acquisition activities to include the development of program acquisition strategy, input to the cost estimates, solicitation/RFP development for Contractor studies, and proposal evaluation activities. He may also provide input to the Capabilities Based Assessment process and the JCIDS process. The PHM Engineer also contributes to the development of the MSA Phase technical products.

MSA Phase - Technical Products Required	
SMC PHM Technical Products	**PHM Contributions to Other Organizations' Products**
PHM models; inputs to concept, arch, technology studies & trades	Operational Concepts
System PHM Req'ts (draft)	AoA Studies
PHM risk assessments	Initial Capabilities Doc (ICD) Dev
Inputs to TDS, DMS, TES	DoDAF AVs, CVs, DIVs, OVs,

2. **Technology Development.** During this phase the PHM Engineer continues to provide inputs to and supports the JCIDS process. The PHM Engineer also supports all the engineering activities highlighted within the box titled *Engineering Activities for PHM Development & Design* Figure 27 to commence system definition and development. PHM Engineer develops and contributes to development of the TD Phase technical products.

TD Phase - Technical Products Required	
SMC Technical Products	**PHM Contributions to Other Organizations' Products**
Inputs to ASP TDS, DMS, TES	Inputs to ASP
System Cost Model, LC Cost Estimate / CARD	Operational Concepts
RFP Inputs: SOO; PWS Tasks, CDRLs, DIDs; PHM system & allocated requirements	AoA Studies
PHM Factors for Studies/ Trades	Operational Assessments
System and Service DODAF Views; ISP inputs	Input to SSP & evaluation criteria for SSP)
Planning Inputs: SEP, LCMP, LCSP, Test Plan & Procedures	Input to DoDAF AVs, CVs, DIVs, OVs
Inputs to R&M failure analyses; alternative maintainability solutions, BIT analyses	

The PHM Engineer supports the concept, architectural, technology development, and engineering trades and analyses to ensure the concept, architectural, technology and design solutions:

- Optimize operational readiness through affordable, integrated, embedded diagnostics and prognostics.
- Enable the system architectural solutions to monitor system performance, predict, detect isolate and remedy faults.
- Lead toward firm supportability design characteristics that in the system and design specifications for prognostics & diagnostics capabilities/technologies (including built in test and health state reporting) supporting condition based maintenance.

3. **Engineering & Manufacturing Development.** PHM Engineer continues to provide inputs to and support the JCIDS process. The PHM Engineer supports all the engineering activities highlighted within the box titled *Engineering Activities for Detailed Design* Figure 27 to commence detailed systems definition and development.

EMD Phase - Technical Products Required	
SMC PHM Technical Products	**PHM Contributions to Other Organizations' Products**
Inputs to ASP TDS, DMS, TES	Inputs to ASP
System Cost Model, LC Cost Estimate / CARD	Operational Concepts
RFP Inputs: SOO, PWS Tasks, CDRLs, DIDs; PHM system, allocated, design requirements	AoA Studies
PHM Factors for Studies/ Trades	Operational Assessments
System and Service DODAF Views; TVs, ISP inputs	Input to SSP & evaluation criteria for SSP)
Planning Inputs: SEP, LCMP, LCSP, Test Plan & Procedures	Input to DoDAF AVs, CVs, DIVs, OVs
Assessments of tech baseline engineering changes	Capabilities Production Doc
Inputs to R&M failure analyses; maintainability solutions, BIT	

The PHM Engineer establishes collecting process, whereby he can provide DT&E inputs arrived at, from data required for Knowledge Base (KB) development and supports the JCIDS process. The activities of PHM during this phase are extensive. The PHM Engineer supports the solicitation/RFP development and proposal evaluation activities which include providing the technical inputs including PHM technical requirements, compliance standards and engineering approaches to meet program objectives. PHM Engineer develops and contributes to the development of the EMD Phase technical products.

The PHM Engineer supports the LCMP and LCSP implementation to ensure the technology and design solutions:

- Continue to optimize operational readiness through affordable, integrated, embedded diagnostics and prognostics.
- Effectively monitor system performance, predict, detect, isolate, report, and remedy faults with minimal false alarms.

4. **Production & Deployment, Operations & Support.** PHM Engineer continues to provide inputs to and supports the JCIDS process. The PHM Engineer provides input to CARD as part of Architecture team and supports solicitation/RFP development and proposal evaluation activities. The PHM Engineer contributes to the development of the Produce / O&S Phase technical products.

Produce / O&S Phase - Technical Products Required	
SMC PHM Technical Products	**PHM Contributions to Other Organizations' Products**
CARD inputs	Supportability Analyses Rpt
RFP Inputs: SOO, PWS Tasks, CDRLs, DIDs; PHM system, allocated, design requirements	Operational Assessments
Assessments of tech baseline engineering changes	
Planning Inputs: SEP, LCMP, LCSP; Production & OT&E planning	
GIDEP assessments; Analyses of reliability & test reports	

PHM Engineers' Contributions to Program and Project Management

Each SMC program defines their business model and approach structure based primarily on their program objectives, program and technical challenges, organizational structure, as well as program and engineering planning (SEP, LCSP, LCMP plus detailed PHM planning).

The PHM Engineer develops and implements the PHM program planning to achieve Program Office objectives and requirements. The planning defines the PHM tasks and functions to be performed and products to be developed; timing of tasks, task outputs, resources (skills, tools, equipment, and completion criteria). The PHM Engineer plans tasks to integrate PHM activities within the Program Office, between Contractors and stakeholders. The PHM Engineer plans the tasks to establish and manage PHM models, requirements development, failure precursors and associated technology and design solutions; support SE&I activities, risk management, integration, and system modifications; coordinate the PHM planning with SMC/EN, integrate PHM engineering planning with other functional and acquisition plans (i.e. SEP, ASP, LCMP, LCSP).

Execution of the PHM planning is typically defined through an Operating Instruction which implements SMC and higher level instructions, policies, and directives. The PHM Engineer provides full support to define the program and technical objectives where PHM challenges and risks are known or anticipated. The PHM Engineer assists to establish the business model, develop program planning and schedules, and define and implement program processes. The PMP Engineer ensures the PHM components of the program are appropriately represented in the program plans, program schedules, work breakdown schedules, cost estimates. The PHM Engineer also reports their technical performance and progress. The PHM Engineer shares in the risk management responsibilities to identify, assess, and propose mitigating actions of PHM related risks. They also support the Program Manager's problem identification, resolution, and decision-making processes.

The PHM Engineer contributes to the development of the program management products identified in the Table.

SMC Program Management Products
PMD
SEP, IMP, IMS, WBS
Decision-making & problem solving inputs
Technical progression and issues reporting
LC Cost Estimate (CARDs)
Processes (OIs)
Risk Management Inputs

Acronym List

Acronym	Definition
AA&E	Arms, Ammunition, and Explosives
ACAT	Acquisition Category
ACTDs	Advanced Concept Technology Demonstrations
ADM	Acquisition Decision Memorandum
AF	Air Force
AFI	Air Force Instruction
AFISC	Air Force Inspection and Safety Canter
AFMAN	Air Force Manual
AFOSH	Air Force Occupational Safety and Health
AFOTEC	Air Force Operational Test and Evaluation Center
AFPD	Air Force Policy Directive
AFSC	Air Force Space Command
AFSPC	Air Force Space Command
AFSPCI	Air Force Space Command Instruction
AIAA	American Institute of Aeronautics and Astronautics
AIAS	Acquisition Information Assurance Strategy
AIS	Automated Information System
ANS	American National Standard
AoA	Analysis of Alternative
AoA	Analysis of Alternative
APB	Acquisition Program Baseline
APB	Acquisition Program Baseline
Archs	Architectures
ASD	Acquisition Strategy Document
ASP	Acquisition Strategy Panel
ASTM	American Society for Testing and Materials
AT	Anti-Tamper
ATEA	Anti-Tamper Executive Agent
AV	All View
BIT	Built-in-Test
C&A	Certification and Accreditation
CAE	Component Acquisition Executive
CARD	Cost Analysis Requirements Description
CBA	Capabilities Based Assessment
CBDP	Chemical and Biological Defense Program
CBM	Condition Based Maintenance
CBRN	Chemical, Biological, Radiological, and Nuclear
CCA	Clinger-Cohen Act
CCA Cert	Clinger-Cohen Act Certification
CDD	Capability Development Document
CDR	Critical Design Review
CDRL	Contract Data Requirements Lists
CI	Commercial Items
CIO	Chief Information Officer
CISP	Counterintelligence Support Plan
CJCS	Chairman of the Joint Chiefs of Staff
CJCSI	Chairman of the Joint Chiefs of Staff Instruction
CJCSM	Chairman of the Joint Chiefs of Staff Manual
CL	Confidentiality Level
CLIN	Contract Line Item Number
CMMI	Capability Maturity Model Integration
CNSSI	Committee on National Security Systems Instruction
COEA	Cost and Operational Effectiveness Analysis
COI	Critical Operational Issues
COM	Computer Operation Manual
CONOPS	Cencept of Operations
COPVs	Composite Overwrapped Pressure Vessels
COQ	Cost of Quality
COTS	Commercial Off The Shelf
CPAT	Critical Process Assessment Tool
CPD	Capability Production Document
CPI	Critical Program Information
CPM	Computer Programming Manual
CRD	Capstone Requirements Decument
CRRA	Capability Requirements and Risk Assessments
CSERIAC	Crew System Ergonomics Information Analysis Center
CSP	Cryptography Security Plan
CTEs	Critical Technology Elements

CV	Capability Viewpoint
D&D	Development and Demonstrate
DAA	Designated Accrediting Authority
DAG	Defense Acquisition Guidebook
DASD	Deputy Assistant Secretary of Defense
DAU	Defense Acquisition University
DBDD	Database Design Description
DCID	Director of Central Intelligence Directive
DCMA	Defense Contract Management Agency
DCR	Doctrine, Organization, Training, Materiel, Leadership & Education, Personnel or Facilities (DOTMLPF) Change Recommendation
DDL	Delegation of Disclosure Authority
DDMS	DoD Discovery Metadata Specification
Delta PDR	Delta Preliminary Design Review
DFARS	Defense Federal Acquisition Regulation Supplement
DIACAP	Department of Defense Information Assurance Certification and Accreditation Process
DIACAP/Cert	Department of Defense Information Assurance Certification and Accreditation Process
DID	Date Item Description
DIP	DIACAP Implementation Plan
DISA	Defense Information Systems Agency
DISR	Defense Information Technology Standards Registry
DIVs	Data and Information Viewpoint
DLA	Defense Logistics Agency
DMS	Data Management Strategy
DMS	Data Management Strategy
DMSMS	Diminishing Manufacturing Sources and Material Shortages
DoC	Department of Commerce
DoD	Department of Defense
DoDAF	Department of Defense Architecture Framework
DoDAF OVs	DoD Architecture Framework Operational Views
DoDAF OVs, SVs	Architecture Framework Operational Views, Service Views
DoDD	Department of Defense Directive
DoDI	Department of Defense Instruction
DoDR	Department of Defense Regulations
DOT&E	Office of the Director, Operational Test and Evaluation
DOTMLPF	Dectrine, Organization, Training, Materiel, Leadership & Education, Personnel or Facilities
DPA	Destructive Physical Analysis
DR	Deficiency Reporting
DRIS	Deficiency Reporting and Investigating System
DT&E	Developmental Test and Evaluation
EBA&D	Ensign-Bickford Aerospace and Defense Company
ECPSSR	Engineering Change Proposal System Safety Report
EIAP	Environmental Impact Analysis Process
EIAs	Environmental Impact Assessments
EIDTR	USAF Enterprise Information Technology Data Repository
EISP	Enhanced Information Support Plan
EM	Electromagnetic
eMASS	Enterprise Mission Assurance Support Service
EMC	Electromagnetic Compatibility
EMC/EMI	Electromagnetic Compatibility/Interference
EMCE	Electromagnetic Compatibility Engineer
EMD	Engineering and Manufacturing Development
EME	Electromagnetic Environment
EMI	Electromagnetic Interference
EMICP	Electromagnetic Interference Control Procedures
EMITP	Electromagnetic Interference Test Procedures
EMITR	Electromagnetic Interference Test Report
EMP	Electromagnetic Pulse
EMV	Electromagnetic Vulnerability
EN	SMC/Engineering
EOLP	End of Life Plan
EP	Electronic Protection
ESD	Electrostatic Discharge
ESOH	Environmental, Safety, and Oporational Health
FEM	Finite Element Modeling
FIPS	Federal Information Processing Standards
FMEA	Failure Mode and Effects Analysis
FOC	Full Operational Capability
FOM	Figure of Merit

FRACAS	Failure Reporting And Corrective Action System
FRB	Failure Review Board
FSM	Firmware Support Manual
FTSR	Flight Termination System Report
GFE	Government Furnished Equipment
GIDEP	Government-Industry Data Exchange Program
GIG	Global information Grid
HAMS	Hardness Assurance, Maintenance, and Surveillance
HAND	High Altitude Nuclear Detonation
HARs	Hardware Acceptance Reviews
HAZMAT	Hazardous Materials
HDBK	Handbook
HE	Human Engineering
HEMP	High-Altitude Electromagnetic Pulse
HERF	Hazards of Electromagnetic Radiation to Fuel
HERO	Hazards of Electromagnetic Radiation to Ordnance
HERP	Hazards of Electromagnetic Radiation to Personnel
HFE	Human Factors Engineering
HHA	Health Hazard Assessment
HHAR	Health Hazard Assessment Report
HMMP	Hazardous Materials Management Program
HN	Host Nation
HSI	Human Systems Integration
HSIP	Human Systems Integration Plan
HW	Hardware
I&S	Interoperability and Supportability
I&S/NC	Interoperability and Supportability / Net Centric
IA	Information Assurance
IAE	Information Assurance Engineer
IAM	Information Assurance Manager
IAS	Information Assurance Strategy
IATT	Interim Authority to Test
IAW	In accordance with
IC	Initial Capabilities
ICD	Initial Capabilities Document
ICW	Interactive Courseware
IDD	Interface Design Description
IEEE	Institute of Electrical and Electronics Engineers
ILS	Integrated Logistics Support
ILSP	Integrated Logistic Support Plan
IMP	Integrated Master Plan
IMS	Integrated Master Schedule
IOC	Initial Operational Capability
IOT&E	Initial Operational Test and Evaluation
IP	Internet Protocol
IPsec	Internet Protocol Security
IPT	Integrated Product/Process Team
IPv6	Internet Protocol version 6
IRS	Interface Requirements Specification
ISO	Information Systems and Organizations
ISO/IEC	International Organization for Standardization/International Electrotechnical Commission
ISP	Information Support Plan
ISSE	Information Systems Security Engineering
IT	Information Technology
ITT	Intograted Test Team
ITU	International Telecommunication Union
IUID	Item Unique Identification
JCIDS	Joint Capabilities Integration Development System
JCPAT-E	Joint C4I Program Assessment Tool - Empowered
JDM	Joint Depot Maintenance
JRMET	Joint Reliability & Maintainability Evaluation Team
JROC	Joint Requirements Oversight Council
KB	Knowledge Base
KPP	Key Performance Parameters
KSA	Key System Attributes
LC	Life Cycle
LC Cost Estimate	Life Cycle Cost Estimate
LCC	Life Cycle Cost
LCMP	Life Cycle Management Plan
LCSP	Life-Cycle Sustainment Plan
LCSSP	Life-Cycle Signature Support Plan
LFT&E	Live Fire Test and Evaluation
LL	Long Lead
LMI	Logistics Management Information

LRU	Line-Replaceable Unit
LSA	Logistics Support Analyst
LSAR	Logistics Support Analyst Report
M&P	Manufacturing and Producibility
M&S	Modeling and Simulation
MAC	Mission Assurance Category
MAIS	Major Automated Information System
MATRIS	Manpower Training Research Information Systems
MCEB	Military Communications-Electronics Board
MDA	Milestone Decision Authority
MDAPs	Major Defense Acquisition Programs
ME	Manufacturing Engineers
MER	Manpower Estimate Report
MfgTech	Manufacturing Technology
Mil-Std	Military Standard
MOAs	Memorandum of Agreements
MOEs	Measures of Effectiveness
MOPs	Measures of Performance
MOSs	Measures of Suitability
MP	Manufacturing and Producibility
MPCP	Mass Properties Control Plan
MRAR	Mishap Risk Assessment Report
MRB	Material Review Board
MRRs	Manufacturing Readiness Reviews
MS	Milestone
MSA	Materiel Solution Analysis
NASIC	National Air and Space Intelligence Center
NC	Net Centric
NCDS	Net-Centric Data Strategy
NCE	Net Centric Engineering
NCES	Net-Centric Enterprise Services
NCOW	Net Centric Operation Warfare
NCW	Net-Centric warfare
NDAA	National Defense Authorization Act
NDIs	Non-Developmental Items
NEPA	National Environmental Policy Act
NEPA EO 12114	National Environmental Policy Act Executive Order
NESI	Net-Centric Enterprise Solutions for Interoperability
NetOps	Network Operations
NISPOM	National Industrial Security Program Operating Manual
NIST	National Institute of Standards and Technology
NR-KPPs	Net Ready-Key Performance Parameters
NSA	National Security Agency
NSS	National Security Systems
NTIA	National Telecommunications and Information Administration
O&M	Operations and Maintenance
O&S	Operations and Support
O&SHA	Occupational Safety and Health Administration
OCD	Operational Concept Description
OFS	Other Findings of Significance
OI	Operating Instructions
OMB	Office of Management and Budget
OPR	Official Person Responsible
OPSEC	DoD Operations Security
ORD	Operational Requirements Document
ORS	Other Recommendations of Significance
OS	Operations and Support
OSD	Office of the Secretary of Defense
OSS&E	Operational Safety, Suitability and Effectiveness
OT	Operational Test
OT&E	Operational Test and Evaluation
OV	Operational Viewpoints
P&D	Production and Deployment
P&D/O&S	Production and Deployment / Operations and Support
PCA	Physical Configuration Audit
PD	Directive
PDR	Preliminary Design Review
PEO	Program Executive Officer
PESHE	Programmatic Environment, Safety and Occupational Health (ESOH) Evaluation
PESHEWG	Program Environmental Safety Health Evaluation Working Group
PGI	Procedures, Guidance, and Information
PHAR	Preliminary Hazard Analysis Report
PHL	Preliminary Hazard List
PHM	Prognostics Health Management
PHS&T	Packaging, Handling, Storage and Transportation

PM	Project Management, Program Management, Project Manager, or Program Manager
PMD	Program Management Directive
PMP	Parts Materials and Processes
PMP	Program Management Plan
PMPCB	Parts Materials and Processes Control Board
PMPSL	Parts Materials and Processes Selection List
PMSDL	Parte, Materials, Selection Data List
POA&M	Plan of Action and Milestones
POC	Point of Contact
PP	Program Protection
PP/AT	Program Protection / Anti-Tamper
PPE	Program Protection Engineering / Program Protection Engineer
PPP	Program Protection Plan
PSM	Product Support Manager
PWS	Performance Work Statement
QA	Quality Assurance
QA/QE	Quality Assurance and Quality Engineer
QAE	Quality Assurance Engineering
QAOE	Quality Assurance Officer/Engineer
QAP	Quality Assurance Program
QATech	Quality Assurance Technical
RAM	Reliability Availability Maintainability
RBD	Reliability Block Diagram
RCM	Reliability Centered Maintenance
RDT&E	Research, Development, Test And Evaluation
REMIS	Reliability And Maintainability Information System Assessments
RF	Radio Frequency
RFP	Request for Proposal
RHOC	Radiation Hardened Oversight Council
RPPOB	Replenishment Parts Purchase or Borrow
RSSP	Replaced System Sustainment Plan
RTP	Research and Technology Protection
S&T	Science And Technology
SAG	Software Acquisition Guidebook
SAR	Safety Assessment Report
SAWE	Society of Allied Weight Engineers
SCD	Specification Control Drawings
SCG	Security Classification Guide
SD	Systems Director
S-D	Spectrum-Dependent
SDAR	Space Debris Assessment Report
SDD	Software Design Description
SDD	System Design Description
SDP	Software Development Plan
SDR	System Design Review
SE	Systems Engineering
SE&I	Systems Engineering and Integration
SED	Specialty Engineering Disciplines
SEP	Systems Engineering Plan
SHA	Safety Hazard Analysis
SIB	Safety Investigation Board
SIGINT	Signals Intelligence
SIM	Serialized Item Management
SIO	Single Investigator
SIP	Software Installation Plan or System Identification Profile
SM	Spectrum Management
SMC	Space And Missile Systems Center
SMC/EN	Space And Missile Systems Center / Engineering
SMCI	Space And Missile Systems Center Instruction
SMD	Standard Microcircuit Drawing
SME	Subject Matter Expert
SOA	Services Oriented Architecture
SOH	Safety and Occupational Health
SOO	Statement of Objectives
SOW	Statement of Work
SPAWAR	Space and Naval Warfare Systems Command
Specs	Specifications
Spectrum Sup Cert	Spectrum Supportability Certification
SPICE	Software Process Improvement Capability Determination
SPO	System Program Office
SPS	Software Product Specification
SQA	Software Quality Assurance
SQE	Software Quality Engineers
SRD	Software Requirements Description
SRDR	Software Resources Data Report

SRR	System Requirements Review
SRS	Software Requirements Specification
SS	Spectrum Suppertability
SSA	Space Situational Awareness
SSA	Source Selection Authority
SSDD	System/Segment Design Description
SSE	System Security Engineering
SSEB	Source Selection Evaluation Board
SSG	System Safety Group
SSHA	System Safety Hazard Analysis
SSHAR	System Safety Hazard Analysis Report
SSL	Space Survivability Levels
SSM	System Safety Manager/Engineer
SSMP	System Safety Management Plan or System Security Management Plan
SSP	Source Selection Plan
SSPP	System Safety Program Plan
SSPPR	System Safety Program Progress Report
SSRA	Spectrum Supportability Risk Assessment
SSS	System/Segment Specification
SSWG	System Safety Working Group
STA	System Threat Assessment
STAR	System Threat Assessment Report
STD	Software Test Description
StdVs	Standards Viewpoints
STIC	Space Technology Integration Council
STIG	Security Technical Implementation Guides
STP	Software Test Plan
STR	Software Test Report
STrP	Software Transition Plan
SUM	Software User Manual
SV	Systems and Services Viewpoint, or Space Vehicle
SvcV	Services Viewpoint
SVD	Software Version Description
SVPP	Survivability and Vulnerability Program Plan
SW	Software
SWAMP	Software Acquisition Management Plan
SysML	Systems Modeling Language
T&E	Test and Evaluation
TA/CP	Technology Assessment and Control Plan
TAFIM	Technical Architecture Framework for Information Management
TBA	to be addressed
TBD	to be developed, or to be determined
TD	Technology Development
TDS	Technology Development Strategy
TDSB	Test Data Scoring Board
TEMP	Test and Evaluation Master Plan
TEO	Technology Executive Officer
TES	Test and Evaluation Strategy
TISP	Tailored Information Support Plan
TMCR	Technical Manual Contract Requirements
TO	Technical Orders
TOA	Turnover Agreement
TOC	Total Ownership Cost
TPIPT	Technical Planning Integrated Product Team
TRA	Technology Readiness Assessment
Traceability Rqts	Traceability Requirements
TRD	Technical Requirements Document
TRL	Technical Readiness Level
TRR	Test Readiness Reviews
TSP	Transition Support Plan
TT&C	Tracking, Telemetry, and Command
TVs	Technical Standards View
UML	Unified Modeling Language
US	United States
USAF	United States Air Force
USC	United States Code
V&V	Verification and Validation
WBS	Work Breakdown Structures
WDSSR	Waiver or Deviation System Safety Report
WizOrd	EBA&D developed Intelligent Electronic Initiation System

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